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ORIGINAL ARTICLES.

I.—The Origin of Mountains.

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1. The reply by the Rev. O. Fisher (Geological Magazine, June, 1913, p. 250) to Sir Thomas Holland's note leads me to ask permission to place the geodetic case before your geological readers. I ask geologists to give a hearing to a geodetic computer.

No living man has done more to encourage geodesists and to create a geological interest in their work than Osmond Fisher; no man has done so much to impress upon geologists that they cannot afford to ignore geodetic results as he has; no other man has had the advantage of being able to speak with authority both as a mathematician and as a geologist. We recognize the weight of his opinion. May I explain why we have the presumption to differ from some of his conclusions?

2. Mr. Fisher has explained the origin of mountain ranges by what is known as the 'floating crust hypothesis', in which he assumes a solid crust floating upon a liquid substratum. He accepts the principle of isostasy in its entirety, and holds that mountain ranges are supported, not by the rigidity of the earth, but by floatation like icebergs.

Geodetic computers find three objections to Mr. Fisher's hypothesis: Firstly, we think that no hypothesis can be accepted now that is dependent upon the assumption of a liquid interior to the earth, and in this point we are in agreement with Sir Thomas Holland. Secondly, Fisher's hypothesis is not generally applicable to all continents and to all mountains, but has to be 'amplified' or 'modified' when any particular topographical feature comes under analysis. Thirdly, Fisher assumes that the depth of compensation of a mountain is directly proportional to its height above sea-level; this assumption is opposed to the results of geodetic observations.

3. Mr. Fisher has argued that the rotation of the earth will give to the liquid interior an effective rigidity; but this rotation has conferred no rigidity upon our oceans, and even if it did render the liquid interior rigid, it would only do so in low latitudes where the rotation velocity is high. I understand, moreover, that the earth's interior was assumed by Mr. Fisher to be liquid, in order to explain the floatation of the crust. If the liquid is now proved to be rigid, the crust cannot be floating upon it.

4. I said above that Mr. Fisher's theory is not generally applicable: may I explain what I mean? If he would define his theory in

general terms, such as the following—"Every topographical feature standing above sea-level is compensated by an underlying deficiency of density, and that deficiency is uniform to a depth equal to ten times the height of the feature"—the geodetic computer could grapple with the problem. It is true that the basis of the Fisher theory is that each mountain has an attenuated root, and the depth of this root is always equal approximately to ten times the height of the mountain above it; but when computers come to apply this theory to actual topographical features they are met everywhere with local exceptions. In Northern India alone we have three such local exceptions: (1) The compensation of the Himalayas is said by Mr. Fisher to exist not only under the mountains themselves but to extend laterally beyond the Himalayan region. How can computers test a theory when the limits and size of the roots are not exactly defined? (2) According to Mr. Fisher's general proposition mountains have roots and valleys have none. But the Ganges valley is an exception; here the alluvial deposits are said to have been so heavy as to press downwards into the liquid substratum. It has thus a root of deficient density, just as if it were a mountain. How can computers deal with a valley that is not in accord with the general theory? If one valley is taken to be an exception to the general theory, how many others are to be treated as exceptions? (3) An advocate of the Fisher theory, writing in *Nature*, May 8, 1913, discusses the Himalayas and their isostatic compensation. He then dismisses the Vindhya Mountains and their compensation as though they presented a different problem to be treated differently. But geodetic computers cannot alter their formulæ to suit every geological peculiarity; they must be given a general theory which is applicable to the Himalayas, Vindhyas, Alps, and other ranges. They cannot compute Himalayan effects alone, and subsequently examine Vindhyan effects alone, for the two are interdependent. Computers have to regard Asia as a whole, and deal with it as such.

5. Two theories of mountain compensation have been placed before geodesists—Mr. Hayford's and Mr. Fisher's. According to the former the depth of compensation is everywhere the same, namely 70 miles, but the degree of compensation is larger for high mountains than for low. According to Mr. Fisher's theory the degree of compensation is always the same, but the depth to which that compensation extends is greater for high mountains than for low. Mr. Hayford varies the amount of compensation by altering its degree; Mr. Fisher varies it by altering its depth.

Now if we test these two theories as stated above by the geodetic results of America and India we find Hayford's strongly supported and Fisher's contradicted. Hayford's theory assumes constancy of depth, and this assumption we find borne out. Fisher's assumes a greater depth of compensation for high mountains than for low, and this we do not find borne out. Hayford's theory is applicable to a solid globe; Fisher's is not. Hayford's has explained both the large negative values of g that have been always found by observation to exist in the interiors of continents, and also the large positive

values of g that have been met with on islands and coasts. Fisher's theory does not explain these anomalies.[1]

6. Although Mr. Hayford has shown that continents and mountains are generally compensated, yet we have no grounds for assuming that mountains maintain a constant height. The author of the theory of isostasy said that it was not intended to account for the origin of mountains, and that it was only put forward to explain how existing mountains were maintained. It has even been argued by others that as material is removed from peaks and crests by denudation the mountains become lighter and in consequence higher. This seems to me to be an unwarranted assumption based on no data whatever. In a similar way it has been stated that the rock floors of river valleys continue to sink as silt is deposited upon them, the underlying idea being that the weight of every additional layer of silt deposited is too much for the solid crust to support, and that the latter yields in consequence. Deep boreholes have been sunk in the deltas of certain rivers, and bones, shells, and remains of plants have been found at all levels, however deep the boreholes have been taken; the conclusion has been drawn that these remains were originally deposited at sea-level.

But let us consider the case of the Plains of Northern India. These extensive plains are deposits of silt brought down by rivers from the Himalayas. Boreholes have been sunk and remains of organic life found buried at great depths in the silt, but these observations do not justify the assumption that the rock-floors underlying the Indus–Ganges Valleys have been continually sinking under the increasing weight of the deposits. Both on the west and on the east long, deep, narrow, submarine troughs extend out into the oceans in continuation of the Indus and Ganges Valleys. The waters of the Indus and Ganges are continually pouring silt into these deep troughs; amongst the silt are remains of organic life that once flourished at sea-level—plants, shells, bones—and these are being deposited at great depths in the troughs. With this going on before our eyes how can we presume to argue that the remains found at great depths in boreholes were originally deposited at sea-level? The simplest explanation is that the plains of Northern India are concealing a sub-crustal crack, that the submarine troughs are continuations of this crack, and that as the crack has opened and grown deeper the deposits filling it up have been continually sinking to lower levels.

7. The problem of isostasy that is now requiring solution may be stated as follows: "Continents and mountains have been found to be compensated by underlying deficiencies of density; how has this condition resembling hydrostatic equilibrium arisen upon a solid

[1] Although Hayford's theory is the nearest approach to truth that has yet been made, it does not afford a complete explanation of every observed anomaly. In my paper on the origin of the Himalayas I corrected all geodetic results in accordance with the Hayfordian system, and I then regarded the uneliminated residuals as indications of actual departures from isostasy. Mr. Fisher calls attention to a change in the observed value of g at Dehra Dun that has taken place between 1870 and 1904. This change is, however, apparent only; it is due to the recent introduction of a correction for the vibration of the brick pillar upon which the pendulum is swung.

globe of rock?" The cores of continents and mountains are found generally to consist of crystalline igneous rocks, and the simplest explanation of isostasy seems to be that these crystalline igneous rocks have arisen from below by vertical expansion. I beg to suggest that if great cracks occur at depths of miles in the sub-crust the rocks may be so disturbed by lateral pressure as to undergo chemical change, and to expand vertically. Mr. Fisher argues that lateral pressure should lead to increase of density. If rock be subjected to compression from all sides its density would increase, but if the pressure is from one side only, and the rock is able to escape vertically, an increase of density may not ensue.

8. Mr. Fisher states that any *deep* rift in our globe must at once be filled by heavy intrusive molten rock rising from below. He cannot accept the view that the solid globe may be cracking, and that the cracks are being filled by material from *above*. But is the intrusion of molten rock from below dependent at all upon depth? Such intrusions are to be seen at high continental altitudes, whilst the great oceanic deeps remain unfilled by them.

It is, I think, conceivable that the outer shells of a solid planet might become cracked in all directions, and that if the planet were devoid of atmosphere and oceans, as Mars possibly is, the cracks on its surface might be visible. If the outer shells of a solid globe were cracking, a condition resembling hydrostatic equilibrium might be produced. As a crack was opening the lateral pressure would suffice to increase the elevation of ridges along its edges, and when the opening force declined the weight of the elevated ridges would tend to close the crack. There would thus be a resilience that would lead to oscillations of level.

9. Suess has suggested that the Himalaya Mountains are advancing southwards, and that the Japanese Islands are moving outwards towards the Pacific Ocean. The geodetic observations in India lead me, however, to believe that the Himalaya Mountains are being forced northwards by the opening of the Indus–Ganges crack, and that the Japanese Islands are being pressed backwards against the continent of Asia by the opening of the Tuscarora Deep. I think that the elevation of the Japanese Islands and their movement westwards as the Tuscarora Deep opens, may possibly teach us how continents and mountains originate and grow.

II.—The Beaufort Beds of the Karroo System of South Africa.

By D. M. S. Watson, M.Sc., Lecturer in Vertebrate Palæontology in University College, London.

THE great Karroo System of South Africa was divided by its discoverer, Andrew Geddes Bain, into four formations on lithological characters. They are—

The Stormberg Series.
The Beaufort Beds.
The Ecca Beds.
The Dwyka Series.

It has long been recognized that the Dwyka conglomerate, which forms a large part of the lowest series, is of glacial origin, and the

common occurrence of smoothed and striated pavements below it all along its northern exposure seems to show that it is the product of a great continental ice-sheet.

It is my purpose in the present paper to discuss the mode of origin of the Beaufort Beds. These beds, which have long been famous for the wonderful reptilian fauna which they contain, form the greater part of the Karroo and Orange Free State.

The whole series has a thickness of roughly 9,000 feet, the great bulk of which is composed of mudstones. These rocks are usually of very fine grain and, as a rule, are not bedded; they often show banding, a difference of colour and texture, but are very seldom bedded; that is to say, it is usually impossible to expose a flat level surface of them, for they break into small cubical pieces so as to leave a quite irregular face. They are broken up by sandstones, usually impersistent, and usually also of very fine grain. In the middle of the series, on Great Winterberg, and also, so Dr. Broom informs me, on the Compass Berg, is a much more powerful development of sandstones of a massive kind and generally of coarser grain.

The colour of the lower beds is usually dark grey or olive, the sandstones being of the same colour on fresh fractures, although they weather brown. The middle of the series, with the thick sandstone mentioned above, is of a lighter tone, the sandstone being yellow and the shales light green or red. The top of the series is almost entirely red in colour, with some green and yellow beds of sandstone and occasional purplish layers.

Many unusual rock-types occur. In the upper beds the sandstones are almost invariably cornstones; that is to say, the angular sand-grains are scattered irregularly in an ophitic manner through large calcite crystals, whose cleavage remains quite apparent. The type is exactly similar to that found in the Upper Old Red Sandstone of Forfarshire.

Another type of cornstone, resembling some of those in the Lower Old Red of Herefordshire, in which the crystals are not apparent and the included material is very fine mud, if any is present at all, is also common in the upper beds, where it often surrounds bones.

In certain places masses of mudstone, usually of a purplish colour, are found, which are penetrated by irregular strings of calcite running in the main more or less vertically, but often branching and having the appearance of the roots of a plant. In one case (Donnybrook, Upper Zwoort Kei, District Queenstown) I found in association with such a rock reniform masses of clear crystalline calcite, about 4 cm. in diameter, in a deep red mudstone.

In the lower beds the mudstones contain immense numbers of nodules of irregular shapes, which are very hard and apparently only slightly calcareous; they sometimes surround bones, and their intractable nature adds much to the difficulty of working on South African fossil reptiles.

Clay-pellet conglomerates are common, particularly in the upper beds, where they often contain small fragments of bone. Pebbles are almost entirely absent; except for two or three found by Dr. Broom, none are known from this thick and very widely spread system.

The most remarkable features of the fossil contents which bear on the problem are—

1. The extraordinary rarity of Mollusca. During my own rather extended visit I saw no fossil shell of any kind, although they were carefully searched for. Dr. Broom, whose experience of the beds is unrivalled, has, I believe, only found one occurrence; and Mr. Whaits, in the course of a very considerable examination of the lower zones, has never met with them.

2. Fish are very rare. The only large group, that from the Caledon River described by Dr. Broom, is contained in bedded sandstones, and judging from specimens in museums those from other horizons are also usually in bedded shales and sandstones.

3. The great rarity of plant-remains, except in the clay-gall conglomerates, where pieces of wood are often seen. The only plant known to have been found in one of the mudstones that I am acquainted with is a bit of *Schizoneura* stem from Kuilspoort, District Beaufort West.

4. The fact that the definitely stratified shales very rarely yield any Tetrapod remains. Dr. Broom states that reptilian bones usually occur just below a sandstone, at the top of a mass of unstratified mudstone. This statement has been controverted by the Survey, but so far as my own observations go they support it, at any rate for the lower beds.

5. Tetrapod remains occur sporadically, and very large areas are practically free from them, although the rocks may be quite similar to those of the same age which are richly fossiliferous in other areas.

6. Reptilian remains often occur in associated sets. In museums such groups are very rare, but this is largely because the great majority of fossils are picked up completely weathered out, and the nodule containing the skull is the most obvious part. The very careful collecting of Mr. Whaits from the *Endothiodon* beds of the Beaufort West flats shows that by picking up all the small pieces of bone within a large area it is often possible to recover a good deal of the skeleton, even of such completely weathered-out specimens; the individuals are so rare that the chance of mixing the bones of two of them is comparatively slight. Where the face on which a fossil is exposed is steep, it is difficult to discover how much of a scattered skeleton is present. In my own experience bones found in situ were almost always associated with other parts of the skeleton. A. G. Bain's original manuscript catalogues show conclusively that many of the bones he sent to England were in associated lots. Reptilian remains sometimes occur in small groups, two or three individuals of the same or different individuals lying close together.

7. The fact that a much larger percentage of the bones found in sandstones belong to Stegocephalia than is the case with those in mudstones. I first noticed this fact in the upper beds of the Burghersdorp district, and examination of the remains in museums seems to confirm it very strikingly.

The problem of the mode of origin of the rocks which present the

remarkable features detailed above is a difficult one. Bain in his first paper recognized that they were not of marine origin because of the entire absence of all salt-water shells. He considered them of lacustrine origin, an explanation which seems to have satisfied most observers to the present day. Stow, however, seems to have been doubtful about it.

It is interesting to compare the features of the Beaufort Beds recorded above with those of the Tertiary deposits of the Great Plains region of North America, also formerly considered as lacustrine. With suitable modification the following quotation from Leidy relating to them will apply to the Beaufort Series: "Whilst the geological formation makes it appear that the fossils were deposited in ancient lakes, or in estuaries or streams connected with the latter, it is strange that they exhibit no traces of fishes or of aquatic molluscs intermingled with the multitude of relics of terrestrial animals. . . . Even mammals of decidedly aquatic habitat are absent; with the exception of the shore-living rhinoceros and the beaver, no amphibious mammals have been discovered. Whilst the fossil bones are in perfect preservation, their original sharpness of outline without the slightest trace of erosion indicates quiet water with a soft muddy bottom." The work of Matthew, Fraas, and Hatcher has shown conclusively that these deposits are not of lacustrine origin, but were laid down on vast flat plains as flood-plain and river-channel deposits modified by wind-action. Matthew has shown that the river-channel sandstones contain the remains of forest- and river-living animals, whilst the fine clays enclose the skeletons of plain-living types.

The whole of the lines of evidence used by these geologists applies *mutatis mutandis* to the Beaufort Series. The vast majority of the Karroo reptiles are dry-land types. *Dicynodon*, which occurs throughout the entire series, is a large and very diverse genus, into which the Scotch *Gordonia* could be put; some of the South African types are, in fact, very similar to that form. *Gordonia* occurs in a sandstone all the grains of which are large and rounded, and in which the pebbles, occurring in thin impersistent bands, are all of characteristically wind-cut shapes; in fact, there is every reason to suppose that *Gordonia* is a desert animal. There can therefore be no doubt that *Dicynodon* is also a dry-land type.

Besides the Pelecypods and fishes, the only types that we have any reason at all for regarding as aquatic are *Lystrosaurus* and the Stegocephalia, the presence of lateral line sense-organs on the skulls of which shows that they must have been to some extent water-living.

I have pointed out above that the remains of fishes are apparently confined to the stratified shales and sandstones, and that the Stegocephalia, which are never common, are proportionately less rare in the sandstones.

Of the only two *Lystrosaurus* localities I visited, one was in very obviously bedded sandstones, the other in sandstone and not so well-bedded shales. The thick mass of sandstone referred to above as occurring on the Great Winterberg is apparently in the zone which yields this reptile.

We have therefore in the stratified and unstratified beds something of the same kind of difference of fauna that there is between Matthew's river-channel and flood-plain types of deposits.

The position in which skeletons are found is of interest. I know the position of seven skeletons of *Pariasaurus* as when found. In all cases the animal, which is a typical land-type, lay with its back upwards and its limbs still articulated; one skeleton that I collected lay prone, with its forelegs symmetrically disposed, the humeri at right angles to the body, and the forearms and hands stretched forward parallel to it. The ribs were naturally disposed, and the two femora lay forward in contact with the body, with the legs stretched out sideways. The whole skeleton, except for the skull, which had been weathered out, was absolutely complete, and looked as if the animal had died quietly, and been covered up without the slightest disturbance by brown dust.

A skeleton of *Procolophon*, only about 25 cm. long, lies absolutely complete, with every bone articulated, in the position dead lizards usually assume, with the hind-limbs stretched backwards along the tail and the soles of the feet inward. Had the Beaufort Beds been deposited in a lake, the places where these skeletons were found would have been more than a hundred miles from its shore; is it conceivable that they could have been transported this distance and then deposited in the exact position in which they died?

The extreme fineness of all the sediments implies that the agent which deposited them was incapable of moving anything larger than a small sand-grain; is it conceivable that it could have carried along the huge bones of *Pariasaurus* and the Deinocephalia?

Had the Beaufort Beds been deposited in a huge lake, we should expect to find very finely bedded shales full of plants, shells, and fishes, and containing occasional scattered bones; instead we find great masses of unstratified rocks with many sets of associated bones, and only very rarely, and then in stratified beds, fishes and plants.

The whole series of facts adduced above appear to me to be quite inexplicable on any lake theory of their origin, but receive a ready explanation if we suppose the deposits to have been laid down on land largely by wind-action, though also to some extent in small lakes or ponds, and perhaps wide and impersistent rivers. I think that it is not improbable that the curious cornstones may have had something to do with an efflorescence of calcareous matter similar to that which is now common in the Karroo.

It may perhaps be interesting to compare the great unbedded masses of mudstone with loess, which they resemble in the fact that their constituent particles are, in the sections I have at present examined, always angular, a common feature in fine wind-borne material.

In conclusion, I have to express my thanks to the Percy Sladen Trustees who assisted me to visit South Africa, and to many gentlemen there whose advice and assistance were of great service to me. I wish specially to thank Dr. R. Broom, Mr. D. V. Kannemeyer, and the Rev. Mr. Whaits.

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III.—On the genus *Syringothyris*, Winchell.

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(PLATE XII.)

1. Introduction.
2. Historical Review.
3. General Account of the Plate-like Structures in the Pedicle Valve of *Syringothyris*.
4. Detailed Account of the Structure of the Tube-bearing Plate (Transverse Plate) in a specimen of *Syringothyris* aff. *carteri* (Hall).
5. Relation between *Syringothyris* and certain Spirifers; and the Origin of *Syringothyris* in North America.

1. Introduction.

THE following account of the genus *Syringothyris* is the result of work undertaken at the suggestion of Professor T. F. Sibly, and is intended as a preliminary to a revision of the British species of that genus, which I hope to present at some future date.

Although it has long been known that *Syringothyris* possessed a distinctive internal structure referred to as a syrinx, or "a split tube between the dental plates", the exact relations of that structure had not been worked out, and it therefore seemed advisable to obtain a clear understanding of the characters of the genus, before attempting to deal with the mutual relations of its species.

To Professor Sibly I have to express my thanks, not only for his valuable advice and assistance while the work has been in progress, but also for his kindness in placing the necessary material at my disposal for study. My thanks are also due to Dr. A. Smith Woodward, F.R.S., for permission to examine and section specimens in the British Museum (Natural History), South Kensington, and to Mr. R. B. Newton, F.G.S., for assistance in searching the collections in the Museum.

2. Historical Review.

The shell now known as *Syringothyris cuspidata* (Martin) was first described in 1796 by William Martin,[1] who named it *Anomia cuspidata*. The true nature of the fossil Brachiopoda had not at that time been recognized, and Martin regarded his shell as an *Anomia*, comparing its triangular fissure with the hole in the attached valve of that lamellibranch. The type-specimen, which is now preserved in the Sowerby Collection in the British Museum (Natural History),

[1] Martin, 1796, pp. 44–50.

South Kensington, was found in the Carboniferous Limestone of Castleton. It shows only the external characters of the shell; there is no trace of a pseudodeltidium, and the delthyrium is filled with matrix so that the tube-bearing plate which is characteristic of *Syringothyris* cannot be seen.

In 1815 James Sowerby founded his genus *Spirifer*, with *Anomia striata*, Martin, as his genotype,[1] and stated that he suspected *Anomia cuspidata* to have coils similar to those which he had observed in *Anomia striata*. This statement, and the fact that in *Mineral Conchology*, vol. ii, p. 43, 1818, which was published before the paper to the Linnean Society was printed, Sowerby mentioned the species *cuspidatus* as an example of his genus *Spirifer*, led William King,[2] Meek,[3] and others to regard *S. cuspidatus* as the genotype of *Spirifer*; but Davidson[4] has shown that Sowerby always regarded *S. striata* as the type-species of his genus.

Spirifer cuspidatus was mentioned by various authors, but no additional characters were described until 1836, when G. P. Deshayes[5] noted the presence of a plate (the pseudodeltidium) covering the delthyrial fissure.

In 1855 F. M'Coy[6] stated that in *Spirifer cuspidatus* (Martin) the triangular delthyrium often displayed "an internal deep-seated pseudodeltidium". In the absence of a figure, it is not certain whether the structure referred to was the tube-bearing plate, but it is probable that it was since the upper surface of that plate is often seen between the so-called 'dental plates', a little below the level of the cardinal area of the shell.

In 1863 Alexander Winchell[7] described certain fossils from the yellow sandstones beneath the Burlington Limestone (Lower Mississippian) of Iowa. Among these were shells which externally resembled *Spirifer cuspidatus* (Martin), but which possessed, in the pedicle valve, beneath the pseudodeltidium and between the so-called 'dental plates', an arched transverse plate. On the lower surface of this plate were two nearly parallel lamellæ, incurved at their free ends so as to nearly meet, forming a tube, incomplete along its lower surface, and projecting beyond the limits of the plate from which it originated. For these shells Winchell proposed the name *Syringothyris*, in allusion to the split-tube or syrinx, and the large triangular fissure or delthyrium. He named his type-specimen *Syringothyris typa*.

Subsequently Davidson, King, and others observed that *Spirifer cuspidatus* (Martin) possessed a similar plate and syrinx; and these authorities regarded *Syringothyris typa*, Winchell, as synonymous with *Spirifer cuspidatus* (*Syringothyris cuspidata*). Schuchert,[8] however, pointed out small differences which led him to regard these two species as distinct forms. At the same time he concluded that *Syringothyris typa* (1863) was identical with *Spirifer carteri*, Hall (1857), which latter shell first occurs in the Bedford Shale of Ohio (lowest division of the Mississippian). Accepting the specific value

[1] Sowerby, 1818, p. 515.
[2] King, 1850, p. 125.
[3] Meek, 1864, p. 19.
[4] Davidson, vol. i, p. 81.
[5] Deshayes, 1836, p. 368.
[6] M'Coy, 1855, p. 426.
[7] Winchell, 1863, pp. 2–25.
[8] Schuchert, 1889, pp. 28–37.

of the differences between *S. cuspidata*, Martin, and *S. typa*, Winchell, and also the identity of *Syringothyris typa* with *Spirifer carteri*, Hall, *the last-named species, having priority, becomes the type-species of the genus* SYRINGOTHYRIS.

The differences between *Syringothyris carteri* (Hall) and *S. cuspidata* (Martin), as defined by Schuchert, are confined to external characters, and are as follows: the area of the pedicle valve is flat or concave in *S. carteri*, while in *S. cuspidata* it is usually reclined; and in *S. carteri* the lateral slopes of the pedicle valve are slightly convex, while in *S. cuspidata* they are flat or nearly flat. These differences are practically the same as those between *Syringothyris* aff. *cuspidata*, of authors, from the *Cleistopora* and *Zaphrentis* zones of the South-Western Province, and Martin's specimen from the Viséan of Castleton, or *S. cuspidata* from the Carboniferous Limestone (*Syringothyris*-zone ?) of Kildare.

Winchell did not figure any of his specimens, but *Syringothyris typa* has been figured by Hall & Clarke [1] and *S. cuspidata* by Davidson [2] and King [3]

3. General Account of the Plate-like Structures in the Pedicle Valve of *Syringothyris*.

(1) *The Delthyrium and Pseudodeltidium.*—The cardinal area in the pedicle valve of *Syringothyris* is interrupted by a triangular delthyrium as in other brachiopods. It is only on rare occasions that any plate is preserved covering the delthyrium, but occasionally the delthyrium is partly closed by a convex pseudodeltidium, the distal end of which is concave towards the apex of the shell, leaving a semicircular opening between itself and the hinge-line. Specimens in which this plate is preserved have been figured by Hall & Clarke [4] and Davidson.[5] When the pseudodeltidium has been lost two grooves into which its edges fitted can often be seen, one on either side of the delthyrium.

In *Syringothyris cuspidata* the pseudodeltidium has no foramen such as occurs in *Cyrtia*. Davidson [6] figured an internal cast of a pedicle valve from the Carboniferous Limestone of Breedon Hill, in which, he maintained, "the deltidium was in reality perforated by a circular foramen." His specimen shows, however, not a foramen in the pseudodeltidium, but a cast of the syrinx characteristic of *Syringothyris*.

Some authors, for example, King [7] and more recently Woods [8] and Cowper Reed,[9] have used the term deltidium for the covering plate

[1] Hall & Clarke, 1894, pl. xxvi, figs. 6, 7, 10; pl. xxvii, figs. 1–3.
[2] Davidson, vol. ii, pl. viii, figs. 19–24; pl. ix, figs. 1, 2; vol. iv, pl. xxxiii, figs. 1–3.
[3] King, 1868, pls. ii, iii.
[4] Hall & Clarke, 1894, pl. xxvii, fig. 15.
[5] Davidson, vol. iv, pl. xxxiii, fig. 1.
[6] Davidson, vol. ii, pl. viii, footnote, and pl. ix, fig. 1.
[7] King, 1850.
[8] Woods, Palæontology, Invertebrate, p. 157.
[9] Cambridge Natural History, vol. iii, p. 498, 1895.

of the delthyrium in the Telotremata, but Hall & Clarke[1] have shown that 'pseudodeltidium' was proposed by Bronn for the fused condition of the deltidial plates that may occur in the Telotremata, while the term deltidium was intended to be used for the simple pedicle-secreted plate in the Protremata and in some Neotremata. Davidson used the terms indiscriminately, and referred to the plate in *Syringothyris* and the Spirifers generally, sometimes as a deltidium and sometimes as a pseudodeltidium. Hall & Clarke proposed to replace the terms 'deltidial plates' and 'pseudodeltidium' by 'deltaria' and 'deltarium' respectively, but this seems unnecessary if the original definitions of deltidium and pseudodeltidium are adhered to.

(2) *The Delthyrial Supporting-plates.*—Extending from the edges of the delthyrial fissure into the interior of the pedicle valve are the so-called 'dental plates' such as are developed in other brachiopods. They are slightly divergent, and in the neighbourhood of the apex reach the floor of the valve; but as the hinge-line is approached they become very shallow, and are widely separated from the floor of the valve. The function of these plates in the Orthotetids has been discussed by Dr. Ivor Thomas,[2] who suggests that they should be called delthyrial supporting-plates, since their almost complete disappearance before the teeth are reached would make it appear that their function is not so much to support the teeth, as to increase the stability of the area where it is interrupted by the fissure. This would apply with even greater force in the case of *Syringothyris*, where the area is so high; and the term 'delthyrial supporting-plates' will therefore be used in this paper in preference to 'dental plates'.

(3) *The Tube-bearing Plate, or Transverse Plate.*—Connecting the vertical delthyrial supporting-plates is a horizontal plate which extends for from one-half to two-thirds of the distance from the apex to the hinge-line. This plate is not the pseudodeltidium, but lies below it. Its distal end is concave to the apex of the shell, and attached to its lower surface is an incomplete tube which projects for a short distance beyond the limits of the plate. On the upper surface of the plate there is a median longitudinal ridge. In passing from the apex towards the hinge-line the tube-bearing plate gradually plunges beneath the level of the cardinal area.

This tube-bearing plate developed between the delthyrial supporting-plates of *Syringothyris* is the distinctive feature of the genus.

As already mentioned, the general characters of this plate and tube have often been described, but their precise structure and relations have not been understood. This is probably due to the state of preservation of the shells examined. The structural details only become really clear when the shell is preserved in a fine-grained rock of such a colour that any shell structure which may be present is clearly defined. Most of the specimens from Derbyshire and Ireland are unfortunately filled with crystalline calcite, which tends to obscure the internal characters of the shell.

[1] Hall & Clarke, 1894, pp. 327–8.
[2] Ivor Thomas, 1910, pp. 100–1.

4. Detailed Account of the Structure of the Tube-bearing Plate (Transverse Plate) in a specimen of *Syringothyris* aff. *carteri* (Hall). (Plate XII.)

The specimen here described was obtained by Professor T. F. Sibly from the Upper *Cleistopora* Zone (K_2) of the Post Office Quarry at Howle Hill, in the Forest of Dean area, Gloucestershire. It is of a type that is common in the Upper *Cleistopora* Zone and in the *Zaphrentis* Zone of the South-Western Province, and which, as mentioned by Dr. Vaughan,[1] has broad flat ribs on the pedicle valve. This type of shell differs in certain respects (height and convexity of area, etc.) from the Derbyshire and Kildare specimens, and is more nearly related to *Syringothyris carteri* (Hall) than to *S. cuspidata* (Martin). The consideration of these differences is, however, best deferred until a future paper, when the species of *Syringothyris* will be dealt with in detail.

Owing to the nature of the matrix, a fine-grained yellow limestone, and the excellent preservation of the shell substance, the specimen was peculiarly suitable for study of the internal characters.

The pedicle valve of the shell was rubbed down in a plane at right angles to the area, and sections drawn at intervals of about half a millimetre. The beak of the valve was slightly damaged, and the first satisfactory section was obtained at a distance of 4 mm. from the apex. The following sections are selected as illustrating the more important stages. (See Plate XII, Figs. 1–8.)

Figs. 1 and 1*a*. Distance from the apex 4 mm. In this section there are two strong divergent plates crossing the valve from the cardinal area to the floor. Each plate is divided longitudinally into halves by a distinct line. The outside moiety (the true delthyrial supporting-plate) in each case is continuous with the shell substance of the cardinal area, while the inside portion curves over at the top, and meeting its fellow from the opposite side forms an arch-shaped plate (the transverse plate) between the delthyrial supporting-plates, and which when seen from above appears as a septum connecting those plates.

Figs. 2 and 2*a*. Distance from the apex 6 mm. Here the sides of the arch-shaped plate are thinner than the delthyrial supporting-plates, which are themselves thinner than in the previous section. In the transverse portion of the arch there is a circular mark which represents the cavity of a tube, filled and obscured by shelly matter during the subsequent growth of the plate. On the upper surface of the plate there is a slight median ridge, also seen in the subsequent sections.

Figs. 3 and 3*a*. Distance from the apex 11 mm. Between this section and the previous one, the delthyrial supporting-plates have become thinner at their bases, until in the present section one of them fails to reach the floor of the valve. The limbs of the arch-shaped plate are shorter than and thin out against the delthyrial supporting-plates. The outline of the tube or syrinx is very distinct, but its cavity is still filled with shelly matter.

[1] Vaughan, Q.J.G.S., vol. lxi, p. 301, 1905.

Figs. 4 and 4*a*. Distance from the apex 14 mm. The delthyrial supporting-plates are here very short. In the transverse plate the cavity of the tube and its inferior opening are very clear. This section, in which the transverse plate and split tube are perfectly developed, may be taken as *a type-section of the essential characters of the genus*, and constitutes a standard to which sections of other specimens can be referred.

Figs. 5 and 5*a*. Distance from the apex 15 mm. In the sections following that shown in Fig. 3, the limbs of the arch become shorter and shorter until they are mere flattenings of the edges of the transverse plate. The plate itself and the wall of the tube become thinner. The conditions at this stage are shown in Fig. 5.

Figs. 6 and 6*a*, 7 and 7*a*. Distance from the apex 16 and 17 mm. respectively. The transverse plate eventually disappears, except for two small portions, one applied to each of the delthyrial supporting-plates, leaving the syrinx quite free as in Fig. 6. At the same time the syrinx becomes smaller and its walls thinner, while its roof assumes a folded aspect. In Fig. 7 the lateral portions of the transverse plate have disappeared, as have also the side walls of the syrinx, leaving only the roof of the syrinx, continuing as a ridged and folded lamella which becomes gradually smaller and finally disappears. (In this specimen, at a distance of 19 mm. from the apex of the shell.)

In the earlier sections (Figs. 1–3) there is a low ridge on the floor of the valve between the delthyrial supporting-plates. This ridge or crest divides the anterior portion of the muscular impressions, and resembles the median crest which occurs in *Spirifer*, *Productus*, and many other brachiopods, but contrasts very strongly with the elevated median septum which occurs in a similar position in *Spiriferina*.

In a band of dolomite in the Lower *Zaphrentis* Zone (Z_1), exposed in the Cement Works Quarry at Mitcheldean, Glos, internal casts of *Syringothyris* of the type already described are abundant, and many specimens have been collected by Professor Sibly. The shell substance has been removed by solution, but the characters of the shell are very clearly shown by the matrix, with which the valve was filled. The delthyrial supporting-plates and the transverse plate are represented by space, and the cavity of the syrinx by a rod (*r*, Figs. 8, 8*a*) lying in a groove on the surface of the matrix that filled the chamber between the delthyrial supporting-plates. The lower surface of the rod is connected with the floor of the groove by a narrow plate representing the slit in the syrinx. The muscular impressions on the floor of the pedicle valve and the crest which separates them are clearly defined in these casts. It was from a similarly preserved specimen that Davidson inferred the presence of a foramen in the pseudodeltidium of *Syringothyris cuspidata* (see p. 395).

We have seen that the transverse plate of *Syringothyris* arises in the apex of the shell as an arch-shaped plate, between and applied to the delthyrial supporting-plates, but not as an integral part of those plates. The syrinx occurs on the lower surface of the plate,

and is formed by two nearly parallel lamellæ, the free ends of which curve towards one another. As the distance from the apex of the shell increases, the lateral portions of the arch become thinner and shorter until only its roof persists as the tube-bearing or transverse plate—a slightly convex plate, down the centre of which is a median ridge on the upper surface and a slit tube or syrinx on the lower surface. The transverse plate itself then dies out. Its distal end is concave towards the apex of the valve, and the syrinx projects for a short distance beyond it. The slit on the ventral surface of the tube tends to close, and the tube itself to be obscured by the further deposition of shelly matter on the earlier-formed portion of the transverse plate. In discussing the homology of the plate, Winchell[1] stated that in many Spirifers there is "an indication of a longitudinal folding of the dental plates which may produce on one side or the other a laminar process", and he suggested that the plate of *Syringothyris* may be of this nature, but in view of the sections that have been described this view appears to be untenable.

5. Relation between *Syringothyris* and certain Spirifers; and the Origin of *Syringothyris* in North America.

There is, developed between the delthyrial supporting-plates of certain Spirifers, a short transverse plate resembling in position and mode of origin the tube-bearing plate of *Syringothyris*; and the following sections (Plate XII, Figs. 9–11) across the beak of the pedicle valve of *Spirifer duplicicosta*, Phillips, from the Carboniferous Limestone (Viséan) of Park Hill, Derbyshire, may be compared with those of *Syringothyris* (Plate XII, Figs. 1–7).

Fig. 9. Distance from the apex 3 mm. This section should be compared with Fig. 1; at this stage the structure of the two shells is essentially the same.

Fig. 10. Distance from the apex 5 mm. This corresponds in position with Fig. 4, and it will be seen that although the relation between the transverse plate and the delthyrial supporting-plate is the same in each case, there is no trace of a tube in the present section.

Fig. 11. Distance from the apex 8 mm. This section corresponds to a stage between Figs. 5 and 6. The plate is incomplete in the centre owing to its concave extremity as in *Syringothyris*, and in a further section, 11 mm. from the apex, it does not appear at all.

A similar transverse plate was observed by the writer in a large specimen of *Spirifer striata* (Martin) from Kildare. King[2] claimed to have seen in a specimen of *S. striata* a transverse plate in which there was actually a tabular canal, but this has not been verified.

Origin of Syringothyris *in North America.*—The plate just described as occurring in *Spirifer duplicicosta*, Phillips, and *S. striata* (Martin) is also found in many Devonian Spirifers of North America, and has been described and figured by Hall & Clarke,[3] who call it a delthyrial callosity. In North America there appears to have been

[1] Winchell, 1863, p. 7.
[2] King, 1868, p. 18, and pl. ii, fig. 25.
[3] Hall & Clarke, 1894, pls. xxiii, xxiv, etc.

a gradual change from the simple plate extending across the delthyrial fissure in certain Spirifers, e.g. *S. granulosus*, Conrad (from the Hamilton Shale, Upper Middle Devonian), to the tube-bearing plate of *Syringothyris*; while in other forms the plate has persisted without change, and occurs as a simple transverse plate in many Carboniferous Spirifers. A transitional stage is seen in *Spirifer altus*, Hall,[1] where the transverse plate bears on its ventral surface a median longitudinal ridge. Girty,[2] indeed, regards *Spirifer altus*, Hall, as the direct progenitor of *Syringothyris*. The syrinx appears to have arisen by the growth of the lateral margins of the ridge, giving rise to two lamellæ, the free ends of which curled towards one another forming an incomplete tube. In North American Spirifers, therefore, the simple transverse plate developed between the delthyrial supporting-plates in certain Devonian forms gave rise to the tube-bearing plate of *Syringothyris*, and the earliest form in which the syrinx is perfectly developed is *Syringothyris carteri* (Hall) (= *S. typa*, Winchell) from the Bedford Shale (Lower Mississippian) of Ohio, which formation contains a fauna allied to, and apparently in part derived from, the Middle Devonian Hamilton fauna.[3]

In this country, however, the genus *Syringothyris* appears with all its essential characters in the *Cleistopora* Zone of the South-Western Province, and its early development is not known. Its ancestors may yet be found among the Devonian Spirifers of this country or Belgium.

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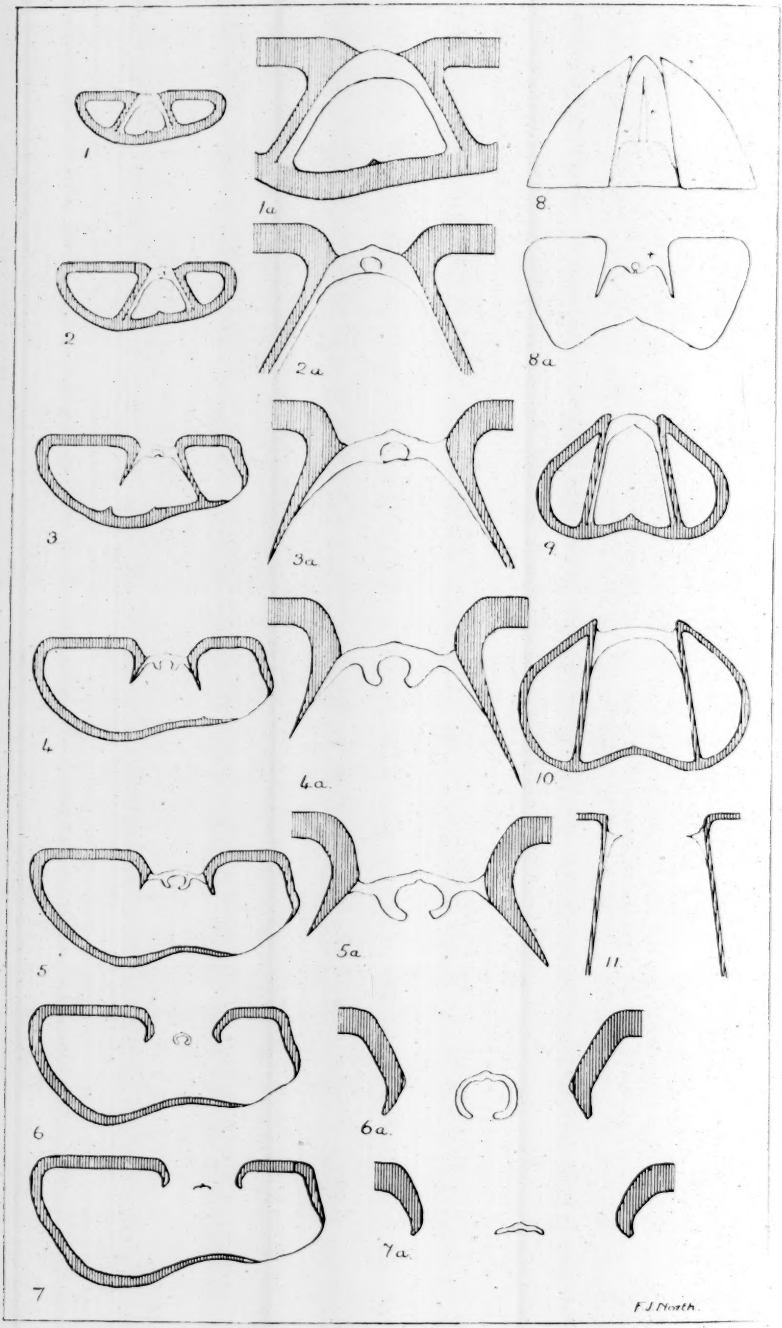
[1] Hall, 1867, pp. 248–9, pl. xliii, figs. 1–7. A form allied on external characters to the European *Spirifer simplex*, Phillips.
[2] Girty, 1900, p. 51.
[3] Bailey Willis, 1912, p. 409.



Transverse sections of the pedicle valve of *Syringothyris* aff. *carteri* (Hall) and *Spirifer duplicicosta*, Phillips.

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EXPLANATION OF PLATE XII.

Figs. 1–7. *Syringothyris* aff. *carteri* (Hall). Carboniferous Limestone Series, Sub-zone K_2: Howle Hill, Forest of Dean area. Transverse sections of pedicle valve. Natural size.
,, 1*a*–7*a*. Delthyrial supporting-plates and tube-bearing plate of the previous sections, enlarged. × 3.
,, 8–8*a*. *Syringothyris* aff. *carteri*, Hall. Z_1. Mitcheldean. Fig. 8, internal cast of the pedicle valve, diagrammatic, showing the rod (*r*) representing the cavity of the syrinx; Fig. 8*a*, transverse section, diagrammatic.
,, 9–11. *Spirifer duplicicosta*, Phillips. Carboniferous Limestone: Park Hill, Derbyshire. Transverse sections of the pedicle valve. × 3. In Fig. 11 only the central portion of the section is indicated.

IV.—The Lower Pliensbachian—'Carixian'—of Charmouth.

By W. D. Lang, M.A., F.G.S.

I. The Green Ammonite Beds.

THE Green Ammonite Beds of the Lias (called also the Wear Cliff Beds in the latest Survey publication on Lyme Regis)[1] include the clays with occasional limestones that lie between the Belemnite Stone below and the lowest of the Three Tiers above. The lowest Tier contains ammonites of the *margaritatus* group,[2] and the Belemnite Stone caps the top beds of the Belemnite Marls that may be placed in the *ibex–valdani* zone.[3] So the Green Ammonite Beds may be said to constitute the upper part of such of the Pliensbachian or Charmouthian as lies below the Domerian.[4] Buckman has applied the term 'Charmouthian' to this lower portion, thus restricting the term to a part only of what it originally included.[5] I have already advocated the propriety of applying the term Charmouthian strictly with its original connotation,[6] and would call those zones of it that lie below the Domerian,—Bonarelli's 'Charmoutiano inferiore'—which certainly need an inclusive name, Carixian.[7] The fullest published accounts of the Green Ammonite Beds are those in the

[1] Woodward & Ussher, *The Geology of the Country near Sidmouth and Lyme Regis* (Mem. Geol. Surv. Eng. and Wales), 1911, 2nd ed., p. 31.

[2] Throughout this paper the phrase "ammonites of the — group" is used, rather than the specific name of the ammonite, implying that several, presumably related forms are included under one designation.

[3] On the evidence of *Acanthopleuroceras ellipticum* (James Sowerby), a form that comes very near to *A. valdani*. Mr. S. S. Buckman kindly identified this form for me.

[4] Bonarelli, Atti della R. Accad. d. Scienze di Torino, vol. xxx, pp. 84–5, 1894.

[5] Buckman, *Yorkshire Type Ammonites*, pt. ii, p. xvi, 1910.

[6] Lang, Geol. Mag., Dec. V, Vol. IX, p. 284, 1912.

[7] "Charmouth, the Carixa of Ravennas" (Roberts, *The History of Lyme Regis, Dorset*, 1823, p. 220). The derivation seems obvious — *Char-isca*, 'Char-river.'

Survey Memoirs,[1] and may be summarized as follows: They extend from Black Ven on the west to Seatown on the east; traces only appear on Black Ven; the complete series occurs on Stonebarrow, though there "only the lower portion is well-exposed"; their thickness is about 100 feet, though variable, and as much as 125 feet to the east of Golden Cap; they consist of marly clays with 'ferruginous bands' and nodular limestones. Eight detailed subdivisions are given.

Now this description in the Survey Memoirs, though excellent as far as it goes, is not of much help for tracing the vertical distribution of the ammonites or other fossils contained in the beds here described; the first step towards which is to be able to tell, when collecting in any section, the exact position in the series of the bed whence the specimens are being taken. For this it is necessary to know what lithic characters are constant throughout the whole exposure of the beds, and what are local accidents; also how the thickness of the whole series varies, so that measurements taken from the same bed at different spots may be correlated. It is proposed to give the stratigraphical results of some years' collecting, both as a guide to future work and to supplement the descriptions in the Survey Memoirs. It may be here remarked that although adding to and even criticizing the account in the Survey Memoirs, this further description would never, probably, have been written without it; and these new subdivisions are now put forward with full acknowledgment of the help obtained from the publications of the Survey.

It must be stated also that the following remarks do not include the Green Ammonite Beds east of Golden Cap. From Golden Cap to Seatown (where they are faulted away)[2] is about a mile, and their total extent in the cliffs about four miles. It is therefore possible that any apparent discrepancies in the Survey Memoir may be due to observations made east of Golden Cap; as is certainly the case with the sandy beds recorded as appearing below the Three Tiers, of which the author has not found more than traces, nor these as a constant feature. Nevertheless, the similarity (except in thickness) of the Green Ammonite Beds from Black Ven through Stonebarrow to Golden Cap is so close that it would be surprising if they changed considerably in that eastern mile.

Three constant and more or less continuous limestones break the monotony of the Green Ammonite clays (see Diagrams I and II). The most conspicuous, continuous, and easily recognized of these is the Red Band. It is well known to the Charmouth fishermen, who, when they want (for sale to visitors) a 'henleyi' as they call ammonites of the *striatus* group, go up Stonebarrow and pick away at the Red Band. There can be no mistaking the curious pink-red weathering of this muddy limestone. When fresh, it is hard and firm; but being only about 6 inches to a foot thick, it is generally weathered nearly to the core, and is then grey-brown and in

[1] Woodward & Ussher, op. cit., 1911; and op. cit., 1906, 1st ed.; H. B. Woodward, *The Lias of England and Wales* (Mem. Geol. Surv. United Kingdom), 1893, p. 68.

[2] See H. B. Woodward, op. cit., 1893, p. 52.

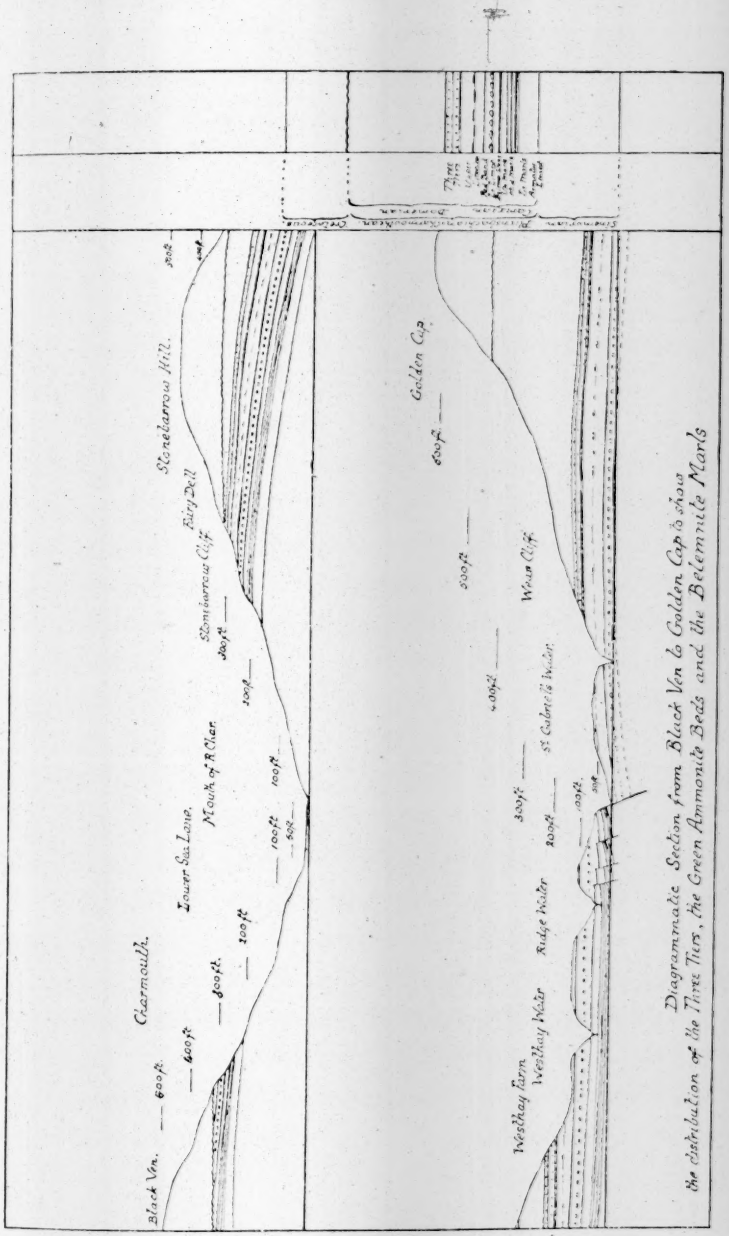


DIAGRAM I: SECTION FROM BLACK VEN TO GOLDEN CAP.
Scale about 3¼ inches to a mile.

a crumbling, muddy condition, becoming pink-red on its surface. A little Crinoid is common and characteristic of it; also a *Nucula*; its commonest ammonites are those of the *striatus* group; *Tragophylloceras loscombi* (James Sowerby) and *Deroceras davæi* (James Sowerby) also occur; as well as *Nautilus* and Gastropods. I have not found the Red Band in place on Black Ven, but fallen blocks may be found above the Lower Limestone at the extreme eastern outcrop of the Green Ammonite Beds on that cliff, showing that it is just included there before the Lias is truncated by the Gault. Some twenty yards west of where the blocks were found there was a section[1] (now unfortunately foundered) showing the junction of the Lias and Gault. The Lower Limestone was to be seen in place some seven feet above the Belemnite Stone, six feet of clay above the Lower Limestone, and then the junction before the Red Band was reached. So the Red Band has a very short range on Black Ven. On Stonebarrow Cliff it may be found west of Fairy Dell,[2] on the slope of broken ground above the precipice formed by the Belemnite Marls, at some height above the 200 ft. contour-line, and followed across the grassy places until, still before Fairy Dell is reached, its outcrop is mostly on the cliff-face. Thence it runs eastward under the more inaccessible parts of Fairy Dell, sometimes on the cliff-face, but generally on broken ground above the clean section. It is conspicuous just above the 100 ft. contour in a semicircular section on the undercliff between Westhay Farm and the sea, close to the 'y' in 'Folly' on the six-inch Ordnance Survey map, and again immediately west of Westhay Water at 105 feet, and may be seen at the head of the gully above the waterfall of that stream. The red weathering of the top and bottom surfaces, in contrast to the grey middle, is so marked in the Red Band as seen near Westhay Water that the Band appears from a distance to be double, a condition it more nearly assumes further east, beyond the Ridge fault. Nearly a quarter of a mile east of Westhay Water is the little waterfall known as Ridge Water, which is in the trough of a syncline, since east of it the beds have a westerly dip. Rather less than 300 yards east of Ridge Water, the cliff ends abruptly in a big fault that lets the beds down about 100 feet[3] on the east. Between Ridge Water and this big fault are three little step-faults with a downthrow on the east of from 10 to 20 feet. They do not, however,

[1] Described, Lang, GEOL. MAG., Dec. V, Vol. I, pp. 125, 126, 1904. It was visited by the Geologists' Association in 1906, see Proc. Geol. Assoc., vol. xix, pt. ix, p. 323.

[2] The great undercliff on Stonebarrow, called 'Cain's Folly' on the six-inch Ordnance Survey map. I use the more familiar local name.

[3] The Survey, following Day (Quart. Journ. Geol. Soc., vol. xix, p. 282, 1863), give a downthrow of only 40 feet (see H. B. Woodward, op. cit., 1911, p. 301); but considering that at this point the Red Band is reckoned at 45 feet above the Belemnite Stone, it must be about 95 feet above the beach on the west side of the fault, while it is beneath the beach 5 or 6 feet below the cliff-base on the east side of the fault; hence 100 feet is a fair minimum estimate of the downthrow. It is possible that there is a second fault a few yards further east, sharing the 100 ft. downthrow with the obvious fault, but this has not yet been definitely ascertained, and at any rate does not affect the present question.

affect the position of the beds as a whole, since owing to their somewhat steep westerly dip these recover between successive faults the distance fallen (see Diagram I). The big Ridge fault brings down the Red Band from the rough ground above the Belemnite Stone to some feet under the beach and out of sight; but at about 50 yards east of the fault it rises from the beach (the dip here is still westerly) on to the low cliff, and in two 6 in. bands about a foot apart, follows this cliff as it rises to some height eastwards, across St. Gabriel's Mouth, and so well up on to Wear Cliff, Golden Cap. Here it is about 40 feet up the cliff, when the dip reverses, and it begins to descend again. The Belemnite Stone may be seen in the angle between the cliff and the beach beneath the western part of Wear Cliff; so at Golden Cap the Red Band is about 40 feet above the Belemnite Stone, whereas at Westhay Water there are 49 feet, at the western end of Stonebarrow only about 20 feet, and on Black Ven but 14 feet between them.

The Lower Limestone, the second constant feature of these beds, is of very different appearance. Sharp, hard, nodular, and impersistent, it presents a marked contrast to the Red Band, which generally is seen in a soft, weathered condition, and occurs in continuous slabs rather than in discontinuous nodules. In spite of its nodular, impersistent nature, the Lower Limestone is remarkably constant in its appearance about half-way between the Belemnite Stone and the Red Band, and may be counted on with certainty in an appropriate section of some size, if it is looked for with care. Its characteristic fossils are ammonites of the *lataecosta* group; it contains also *Tragophylloceras loscombi* (James Sowerby); occasionally, too, a *Straparollus*; but fossils other than ammonites are rare in this rock. It occurs 7 feet above the Belemnite Stone on Black Ven; 10 feet at the western end of Stonebarrow Cliff; 21 feet at Westhay Water (where it is poorly developed and consequently difficult to find); and about 20 feet above the Belemnite Stone on the western face of Golden Cap. After being thrown down by the Ridge fault, it can be picked up rising from the beach some forty yards east of the reappearing Red Band.

The Upper Limestone is less easily found than the Red Band or the Lower Limestone. It appears half-way between the Red Band and the Lowest Tier. Like the Lower Limestone it is often sharp and nodular, but the nodules tend less to a spherical shape. On the western side of Stonebarrow, however, it is either flaggy and tends to be sandy like the Three Tiers, or is nodular and calcareous with a sandy shell; and it may change abruptly within a few yards from one to the other condition. The sandy beds mentioned in the Survey Memoir as occurring below the Three Tiers may be this rock, only they are comparatively higher in the Green Ammonite Beds Series. The Upper Limestone is above the highest Lias on Black Ven; but it may be found at the western end of Stonebarrow 35 feet above the Belemnite Stone or 15 feet below the lowest Tier. The ground, however, at this horizon is very broken on Stonebarrow, and it is not often that a section can be found in it. On the western side of Golden Cap, the Upper Limestone may be found 30 feet below the

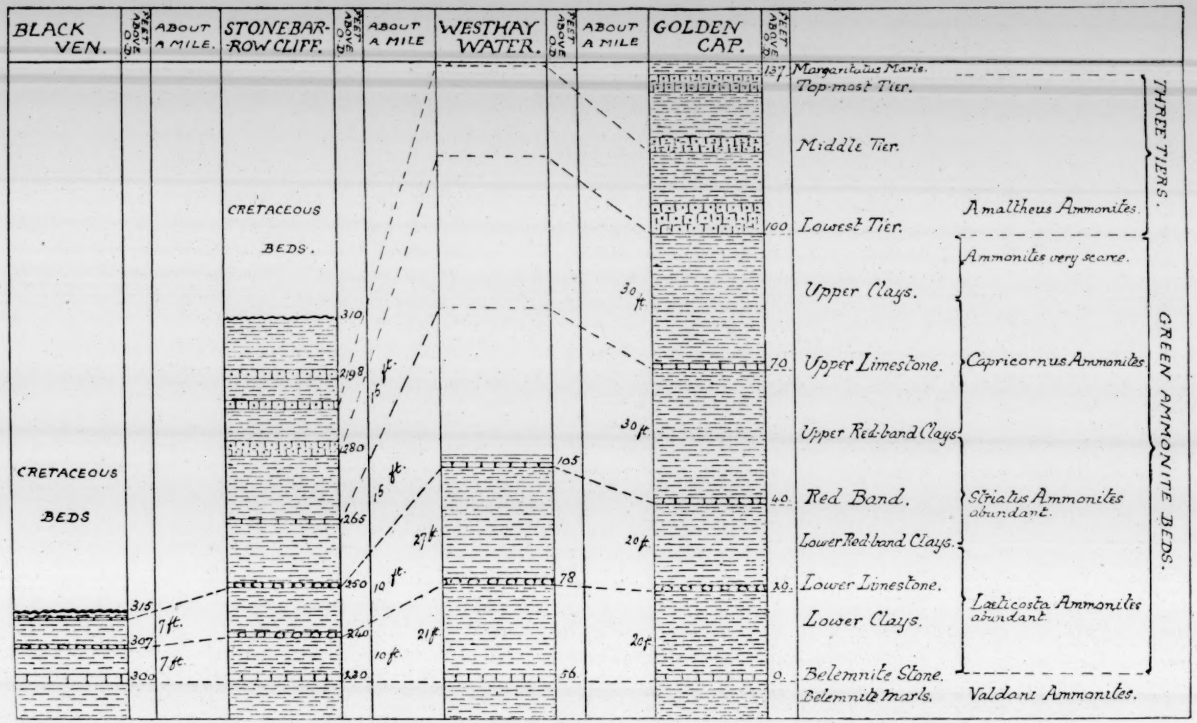


DIAGRAM II: DETAILED SECTIONS OF THE THREE TIERS AND GREEN AMMONITE BEDS, SHOWING THEIR VARYING THICKNESS AT DIFFERENT POINTS.

lowest Tier, and about 70 feet above the beach. The only fossil common in this bed is *Tragophylloceras loscombi* (James Sowerby).

Of the four clay masses included within the Green Ammonite Beds, the topmost, the Upper Clay, contains many *capricornus*-like ammonites, and an *Arca* is fairly common, all in a filmy condition, and small pyritic casts of *Tragophylloceras loscombi* (James Sowerby). The second bed, the Upper Red-Band Clay, has similar fossils and in addition pyritic casts of ammonites of the *bechei* and *latæcosta* groups. The third, the Lower Red-Band Clay, in the upper part contains chiefly well-preserved *T. loscombi* (James Sowerby) and, rarely, *Deroceras davæi* (James Sowerby) in films, and, in the lower part, abundant *Straparollus* of two or three species, other small gastropods, young pyritized *T. loscombi* (James Sowerby), and ammonites of the *latæcosta* group. And the lowest bed, the Lower Clay, fossils similar to those in the lower part of the bed above.

It should be clear from the above description that there is a considerable thinning of the Green Ammonite Beds as they pass westwards.[1] In fact, at the western end of Stonebarrow their thickness is only half of what it is on the western side of Golden Cap; while on Black Ven, what remains of them gives evidence of further and proportional thinning. The variation is not, however, quite regular, since at Westhay Water the series appears to be slightly thicker than on the western face of Golden Cap. This diminution affects the whole series equally, so that the thickness of its subdivisions varies directly with that of the whole. Moreover, the Three Tiers share in the diminution, and may be seen on Stonebarrow shorn of half that development they display on Golden Cap.[2] The lower two Tiers may be seen in place on Stonebarrow Cliff in the banks bordering the great hollow formed by a fall of the cliff (1908–9) beneath the beeches and pine-trees immediately west of Fairy Dell; and the Lowest Tier again on the cliff just west of this. The Lowest may be known from the two higher Tiers by being nearly twice as thick (in the same section) as either of these, and far more fosiliferous. Its chief fossils are ammonites of the *margaritatus* and *loscombi* groups and small gastropods. The Tiers are next seen about a hundred yards further east, at the western end of Fairy Dell, just east of the top of a big gully that makes it possible to climb the Belemnite Marls at this point. The gully is blocked in places by large masses of the Lowest Tier. In the section above it all three Tiers were to be seen in place and a few feet of Margaritatus Marls above them. The section, however, during the last year (1912–13) has foundered and is much obscured. The two higher Tiers with Margaritatus Marls above may be seen again beneath the junction of the Lias and Gault in the Lias bank that breaks through the overgrown expanse of Fairy Dell in its eastern part.

It was conjectured in a former paper[3] that the base of the Cretaceous on Stonebarrow was at about 320 feet O.D. It now appears that this is at least 10 feet too high, and the actual heights are probably

[1] See GEOL. MAG., Dec. V, Vol. IX, p. 285, 1912.
[2] See GEOL. MAG., loc. cit., 1912.
[3] Lang, GEOL. MAG., Dec. V, Vol. IV, p. 150, 1907.

those given in the accompanying diagram. If these are right, the base of the Cretaceous on Stonebarrow is slightly lower than on Black Ven, contrary to Jukes-Browne's surmise. This does not, however, affect the validity of Jukes-Browne's main argument.[1]

It remains to be seen if any correspondence can be established between the sequence given in this paper and the eight subdivisions of the Green Ammonite Beds in the Survey Memoirs. The detailed section given in the Memoirs[2] is about 100 feet thick, of which about one-half is occupied with the two lower divisions. It is safe, then, to assume that the five upper Survey divisions are above the Red Band. The upper three of these are remarkable for exhibiting sandy conditions like the Upper Limestone on parts of Stonebarrow; but they include only 13 feet, whereas the Upper Clay on the west face of Golden Cap is 30 feet thick, and the Upper Limestone should therefore be found towards the bottom of the fourth subdivision of the Survey Memoir, the base of which is 33 feet below the lowest Tier. The 'ferruginous band', the fifth subdivision, is probably a streak of stained clay, since it is 30 feet above where the Red Band should appear. The sixth subdivision contains no hard beds; and the seventh, of indurated marl and limestone, is admittedly 'occasional' and probably, therefore, local, but might be meant for the Red Band. This leaves the eighth and lowest subdivision, measured with the seventh as 54 feet thick. By measurement this bottom 54 feet should include both the Red Band and the Lower Limestone. The latter, presumably, is the "nodules of hard grey limestone", though there is nothing in the description that suggests that they are on one horizon; and the former the 'ferruginous bands', though, even where the Red Band appears to be double, this would be a poor description of that rock. Thus, even if this interpretation is right, it cannot be said that a satisfactory correlation has been established between the two accounts.

II. The Belemnite Marls.

The Belemnite Marls[3] consist of some 80 feet of rock, capped by the Belemnite Stone and bounded beneath by a limestone containing ammonites of the *armatus* group. The Survey assign the Marls to the zones of *armatus*, *jamesoni*, and *ibex*,[4] but do not suggest any lines of demarcation; on the contrary, they speak of "an inosculation of the zones".[5] Six subdivisions are given, however, based on the lithic characters of the beds. In practice it is not easy to be sure of these subdivisions, and the following are suggested as easier to recognize in the field (see Diagram III, p. 409): (1) a lower division, about 40 feet thick, of darker marls—the Lower Marls; (2) a middle division, about 23 feet thick, of paler marls—the Middle Marls; and

[1] This concerns the general shape of the Cretaceous base-line in this district, see Jukes-Browne, Proc. Dorset Nat. Hist. Club, vol. xviii, p. 176, 1897; and Geol. Mag., Dec. IV, Vol. V, p. 164, 1898.

[2] The most detailed account is in H. B. Woodward, op. cit., 1893, p. 69.

[3] The Stonebarrow or Belemnite Beds of the Survey Memoirs.

[4] H. B. Woodward, op. cit., 1893, p. 67.

[5] H. B. Woodward, op. cit., 1893, p. 68.

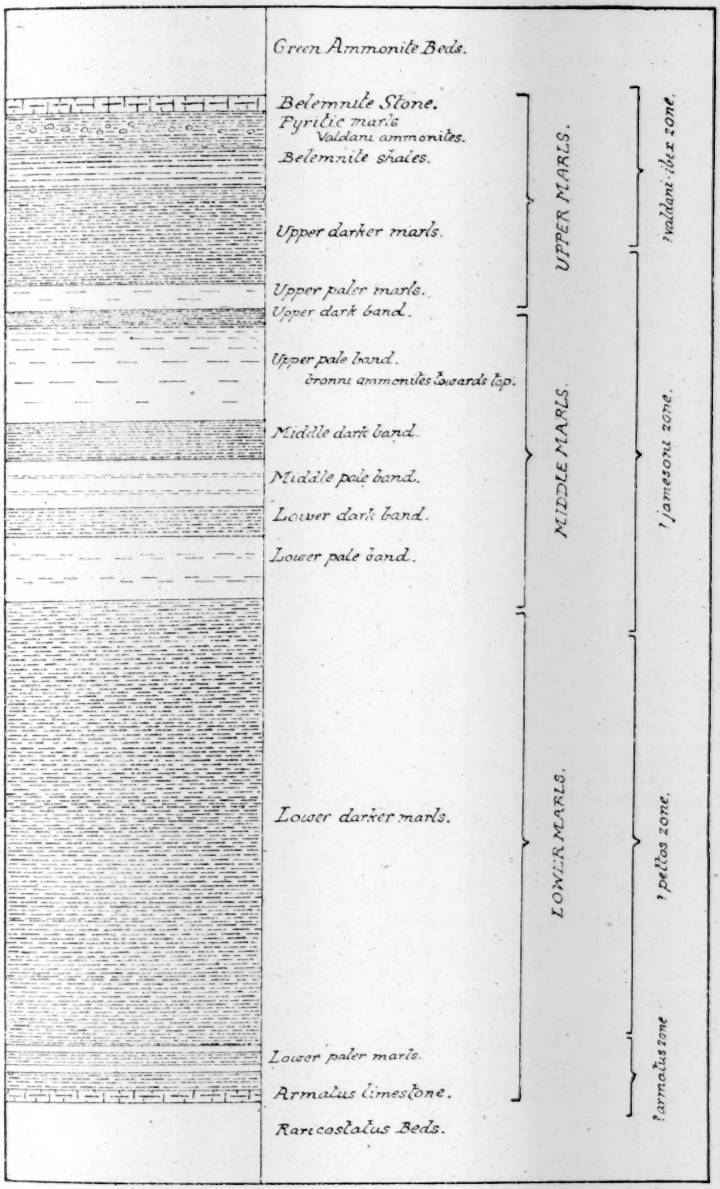


DIAGRAM III: DETAILED SECTION OF THE BELEMNITE MARLS.

(3) the Upper Marls, on the whole darker than the Middle Marls, about 16 feet thick.

The Lower Marls have at their base the Armatus Limestone just mentioned. This rock is rarely exposed on Black Ven and on the western end of Stonebarrow, being generally covered with talus; but it is well shown at the base of the eastern part of Stonebarrow Cliff where it comes down to the beach about a mile east of the mouth of the Char; and it forms a long ledge under the shingle bank between the tide-marks still further east, that is more or less exposed according to the accidents of wave and shingle. It is the home of the "large examples of this Ammonite [*Deroceras armatum*] with prominent spines" whose "particular horizon requires investigation" of the Survey Memoir.[1] The ammonites are poorly preserved, being represented only by a black film, and, since the matrix is comparatively hard, they are difficult to extract satisfactorily. The Armatus Limestone lies a foot or two above the Watch Ammonite Stone (the "Grey, earthy limestone" of the 1893 Memoir, and part of the "Watch-stone Beds" of the later Memoirs), a characteristic Limestone often crowded with Ammonites of the *raricostatus* group. At the base of the Lower Marls, and extending to within a foot of the Armatus Limestone, are one or two pale bands that look like Limestone. They can hardly, however, rank as such, being merely indurated marls, and, although highly calcareous, are quite soft compared with the Armatus Limestone. In fact, there is no definite bed from the Armatus Limestone up to the Belemnite Stone that is anything more than an indurated marl. If these are the "marly limestones and shales" constituting the last two subdivisions of the Belemnite Marls in the Survey Memoirs, the Armatus Limestone is not there recognized.[2] It is better, however, to regard these lowest two subdivisions as including the Armatus Limestone and the pale indurated marls above. These pale indurated marls at the base of the Lower Marls must have some wave-resisting quality in spite of their comparative softness, for they form the shoal called Hawkfish Ledge that lies just off Westhay Water. Owing to the change of the dip here from an easterly direction to nearly horizontal, this ledge, instead of running out seawards at a small angle with the coast, swings round festoon-wise, enclosing a minute roadstead at half-tide. The Armatus Limestone does not appear to form part of Hawkfish Ledge, but makes a reef running seawards of it. Except for the lowest few feet the Lower Marls are dark as a whole and comparatively barren. They yield belemnites and saurian remains, and, at the top, the same *Inoceramus* as the Middle Marls. If, as is possible, the Middle Marls represent the *jamesoni* zone, it is likely that the rare examples of *A. pettos* that have been found beneath Stonebarrow Cliff come from the Lower Marls.

The Middle Marls consist of three thicker pale and three thinner dark bands. The pale bands are very fossiliferous in places, though

[1] Woodward & Ussher, op. cit., 1911, p. 30.

[2] The Survey follow Day in calling these indurated marls, limestones; see Day, Quart. Journ. Geol. Soc., vol. xix, p. 281, 1863. On p. 280, however, Day speaks of "semi-indurated limestone", which is a far less misleading description.

the fossils for the most part are poorly preserved, and are not easy to find in place, however they may abound in fallen blocks. The commonest fossil is *Inoceramus falgeri*, Merian in Escher von der Linth,[1] a large form described from Lias above the Sinemurian of Lechthal, N.E. Switzerland. Several species of Ammonite have been found, but await identification. Since different horizons have yielded different kinds, it is hoped that if the species can be determined, it will be possible to draw zonal lines in this middle division with some exactness. Belemnites are common throughout. The bottom division—the Lower Pale Band—itself is sometimes divided by three still paler beds. It comes to the beach at Ridge Water, and owing to the reversal of the dip at this point rises on to the cliff on each side. It is thrice thrown down again on the east by the small step-faults already mentioned (p. 404) between Ridge Water and the big Ridge fault. The Middle Pale Band is easily recognized by being always divided by three paler beds and two intervening darker beds into five stripes. This feature is constant throughout the whole of its exposure from the western side of Black Ven to the Ridge fault; whereas the Lower Pale Band is only sometimes thus divided, and the Upper Pale Band, if differentiated at all, breaks up into a large number of beds. The Upper Pale Band is the thickest of the three, 8 feet as compared with 5 and 4 feet respectively for the Lower and Middle Pale Bands. It becomes somewhat darker in its upper part, and tends to pass into the Upper Dark Band. In its top portion it contains *Uptonia* aff. *bronni* (Roemer).[2] At about three-quarters of a mile east of the mouth of the Char, the Upper Pale Band is seen to split into about sixteen alternating lighter and darker stripes, but generally it is more or less uniformly pale.

The Upper Marls on the whole are dark. The bottom bed, however, a 2 ft. pale band, is conspicuously contrasted to the 1 ft. Upper Dark Band of the Middle Marls, and with it forms a convenient because easily recognized division between the Upper and Middle Marls. Above the 2 ft. pale band are 8 feet of darker marls, then 3 feet of dark Belemnite Shales, and finally 3 feet of marl with much pyrites capped with the Belemnite Stone. The 3 feet of Pyritic Marl are almost certainly the beds whence have come ammonites of the *valdani* group,[3] preserved in pyrites, that are not uncommonly found on the terrace below the Belemnite Marls. So far but one of these has been found by the author in place—1 foot below the Belemnite Stone. It is probable, then, that the line between the *jamesoni* and *ibex-valdani* zones will be drawn in the lower part

[1] A. Escher von der Linth, "Geol. Bemerkungen u. d. nördliche Vorarlberg und einige angrenzenden Gegenden," 1853, p. 1, pl. i, figs. 1–5. See also W. Ooster, in C. von Fischer-Ooster, "Protozoe Helvetica," vol. i, pt. ii, pl. xii, figs. 1–5, pp. 36, 37, 1869. I am indebted to my colleague, Mr. R. B. Newton, for kindly identifying this form.

[2] The following additional note was added by Mr. S. S. Buckman, who kindly identified this form: "? = young of d'Orbigny's large figure of *Uptonia regnardi*," d'Orbigny, 1842, Pal. Franç. Terr. Jur., p. 257, pl. lxxii, fig. 1.

[3] Mr. S. S. Buckman has kindly examined this form and identified it with *Acanthopleuroceras ellipticum* (James Sowerby), "very near to *A. valdani*."

of the Upper Marls. The Survey Memoir mentions "nodules and impersistent masses of hard grey limestone within two feet of [below] the Belemnite Stone".[1] At about this horizon, at Westhay Water, and forming a shelf at the top of the waterfall, is a lenticular bed of Limestone, 1 to 2 inches thick, largely composed of Crinoid remains.

The Belemnite Marls do not vary much in thickness, as a whole, from their appearance on the western shoulder of Black Ven to their disappearance beneath the beach east of the big Ridge fault; they vary a good deal, however, in the thickness and hardness of individual pale beds, which is probably due to the amount of segregation of calcium carbonate that has taken place; the thicker and paler the bed, the harder and more calcareous it appears. The limestones throughout the Charmouth Lias appear to be of the nature of segregations; the most complete having the form of nodules, like those of the *Stellaris* Beds[2] and the Lower Limestone of the Green Ammonite Beds[3]; the less complete being muddy limestones like those of the *bucklandi* zone (the *Birchii* Bed[2] is an example of a limestone now nodular, now tabular); the still less complete being indurated marls like those under discussion. Table Ledge[4] is a transition from an indurated marl to a muddy limestone.

East of the Ridge fault the Belemnite Stone rises to the foot of the cliff about a quarter of a mile east of St. Gabriel's Mouth, but soon plunges under the beach again, reappearing once more between Golden Cap and Seatown.[5] And the Upper Marls are exposed between the tide-marks under Golden Cap.[6]

It has been suggested that the Armatus Limestone and the indurated marls just above it are included in the two bottom beds of the six subdivisions made by the Survey in the Belemnite Marls. The third division from the bottom probably represents the rest of the Lower Marls, and the fourth division the Lower Pale Band of this paper. The fifth, then, would include the rest of the Middle Marls and all except the top 6 feet of the Upper Marls; and the top division, the Belemnite Shales and the Pyritic Marls. At any rate this correlation is more satisfactory than that attempted for the Green Ammonite Beds.

Finally, I would express my thanks, first to my wife for much help in the field; also to Mr. Thomas Hunter, fisherman, of Charmouth, who has known these cliffs from boyhood and helped E. C. H. Day who first worked them in detail, and for some years from time to time has given me much useful information and advice; and to Mr. L. Spath, F.G.S., for advice in connexion with the ammonites mentioned in the paper; as well as to Mr. S. S. Buckman, F.G.S., and Mr. R. B. Newton, F.G.S., whose help in each case has been indicated in the text of the paper.

[1] H. B. Woodward, op. cit., 1893, p. 68.
[2] H. B. Woodward, op. cit., 1893, p. 65, "*Am. stellaris* in nodules."
[3] See *ante*, pp. 401–2.
[4] H. B. Woodward, op. cit., 1893, p. 60.
[5] H. B. Woodward, op. cit., 1893, p. 52.
[6] H. B. Woodward, op. cit., 1893, p. 66.

V.—Notes on the Geology of the Bermuda Islands.

By Major A. J. Peile, R.A.

I.

In a very interesting article on the Geology of Bermuda, published in this Magazine for September and October, 1911 (pp. 385–95 and 433–42, Pls. XVIII–XXIII), the late Rev. R. Ashington Bullen states, on p. 390, that Admiral's Cave at Spanish Point is in the Walsingham Formation. This statement is evidently due to a slip in map-reading, Admiralty Cove being the boat harbour of Admiralty House near Spanish Point, whereas the Admiral's Cave, whence the *Pœcilozonites nelsoni* in the British Museum were derived, is the "cave near the calabash-tree" mentioned on p. 439. This cave owes its name to the visit of Admiral Milne, and the base of his stalagmite is still in evidence, bearing his tool marks. It is one of the largest and most remarkable of the many caves between Bailey's Bay and Tuckerstown.

With regard to the connexion between these shells and the formation in which they occur, *P. nelsoni* is found in great quantity, associated with a few other species, in a bed of earth far within the cave. It is probable that the earth was washed into the cave through some fissure when the rainfall in the islands was greater than it is at present. It is, however, noteworthy that the shells, which are well coated with a stalagmitic (?) deposit, do not as a rule contain earth. Traces of animal matter have been found in the inner whorls of some of them, and broken specimens often exhibit colour-bands resembling those of the living, but much smaller, *P. bermudensis* and its extinct variety, *P. zonatus*. In fact, the circumstances under which they are found here and in other caves[1] make it unlikely that the shells are contemporaneous with the rocks in which the caves are formed. *P. nelsoni* is also to be found in hard rock, and so are other species, some of which are extinct. In many cases the shells had evidently found their way into crannies in the rock, where they were later cemented in by stalagmitic deposits (*vide* diagram, p. 390). In other cases they appear to be regularly embedded in the mass of the limestone. It is probable that the variations in character of the æolian sandstone, due to chemical deposits from infiltered water, are not always an index of the age of the rock, so that it is just possible that the presence of these shells does not definitely determine a deposit as belonging to the Walsingham Formation, as suggested on p. 390.

It is interesting to note that the small neck of land between Castle Harbour and Harrington Sound, which is honeycombed with caves containing fossil shells, and which differs somewhat in the character of its vegetation from the rest of the islands,[2] is perhaps the only present habitat of two of the species of endemic snails that flourished along with *P. nelsoni*. These are *P. reinianus* and *P. goodei*. Living examples of these two species are hard to come by, but it is

[1] The first *P. nelsoni* recorded were found by Lieut. Nelson in a cave at Ireland Island, at the other end of the islands.

[2] It is sometimes said to be a bit of surviving jungle of the ancient Bermuda.

a suggestive fact that their dead shells may be found in large numbers in crannies in the rocks. The fossil specimens from some localities, but not from others, are larger than the living forms. Two other living species, *P. bermudensis* and *P. circumfirmatus*, are more widely distributed and are fairly common.

A most interesting account of the fossil land shells, by Professor Addison Gulick, is to be found in the Proceedings of the Academy of Natural Science of Philadelphia for July, 1904. There is still work to be done in the study of the varieties of fossil species from different localities and in tracing the connexion between the fossil and living forms.

II.

The analysis of the phosphorite rock, described at the end of the article, suggests an interesting problem. Flat bottoms among the reefs, at any rate in the more sheltered channels and sounds, consist of chalky mud, reduced to its present state in the intestines of the big holothurians, known locally as 'sea cucumbers'. It is possible that a similar origin for the rocks analysed would account for their coprolitic nature. The question of how such an ancient sea bottom came into its present position would still have to be tackled, but the theory now suggested seems at least more tenable than that of deep sea mud referred to as impossible on p. 440.

Although there is every proof that the islands have been sinking during past ages, there have been some slight upheavals, if only local, as evidenced by the so-called Devonshire formations containing marine shells (*vide* p. 393).

VI.—Note on a Buried (East Mercian)[1] River Channel near Peterborough.

By A. Irving, D.Sc., B.A.

In the *Peterborough Advertiser* for December 16, 1911, there appeared an illustrated article on a "recent discovery" of a silted-up pre-glacial river-valley, 250 yards wide, at Fletton, near Peterborough. Eliminating from that article a good deal of scientific romance, there remains a certain residuum of geological facts, so far as the determination of them by the writer of this note has been carried out, through the courtesy of Mr. A. Adams, the Manager of the London Brick Company's works.

The banks of the ancient river appear to be well defined on the north and south sides of the buried channel. Against these there lies a deposit of slimy river-silt derived from the material of the Oxford Clay, through which the river (comparable with the Trent at Newark) had carved out its course. This black silt contains fossils of the Oxford Clay itself, along with shells of *Cardium edule*[2], and

[1] Read at the British Association, Dundee Meeting (1912), Section C.

[2] Determined by Mr. R. B. Newton at the British Museum (Nat. Hist.). Mr. G. Wyman Abbott, of Peterborough, is preparing a paper on the shell-contents of these beds in co-operation with a well-known specialist on recent shells.

considerable masses of lignite, but apparently no boulders. It appears to be of local origin. Its junction with the Oxford Clay in situ is seen in open sections on both sides of the channel, while upwards it is mixed up with the fine stratified river-gravel and sand, which (as interglacial or 'subglacial'[1] deposits) seem by the evidence of well-sections to have filled the pre-glacial valley, as such deposits have filled the pre-glacial valley of the Stort.[2] In *composition* these gravels (so far as examined) agree remarkably with those at Stansted Mountfichet and other places in the upper Stort valley, and like them contain rolled Belemnites, Gryphæas, etc., from the Jurassic rocks. In other respects the gravels have also much in common with the high-level stratified gravels of the Trent at Beeston,[3] where the Jurassic fossils seem to be wanting. In open sections on both sides of the channel these gravels are, in their upper portions, puckered and distorted apparently by frozen masses of gravel of the floating-ice stage of glaciation, agreeing with the facts observed in the upper Stort valley[4] and in the old Windsor Forest country of the Thames outer valley[5] in East Berks.

The facts observed, as recorded in this and previous papers, taken together with the known physiography of the upper Trent basin, seem to suggest inferentially a connexion in late Tertiary times between that and the Thames Valley by way of the buried channel through the Chalk Range[6]; the capture of the Trent by the Humber being accounted for by crustal movements and by the glacial damming, of which the 90 feet of Boulder-clay furnishes evidence, as this was observed years ago by Dr. J. J. Harris Teall and myself, when the Midland Railway from Melton Mowbray to Nottingham was in process of construction. The River Nene above Peterborough appears to cut right across the buried channel, indicating the comparative modernity of the present river-system of the Wash Basin.

* * * * *

My more recent work during the month of August (availing myself of the local knowledge of Mr. G. Wyman Abbott of Peterborough) has led me to conclude—from observations made in the sand and gravel pits known as Anker's Pit and Rippon's Pit (both close to Peterborough) and in London Brick Company's Pit No. 1 at Old Fletton—that the relations of the Nene Valley to the ancient buried channel are not so simple as appears at first sight. In the silted-up Nene Valley, however, the succession of the deposits is roughly as follows:—[7]

[1] N. O. Holst. [2] A. Irving, B.A. Reports for 1910, 1911.

[3] A. Irving, P.G.A., vol. xv, p. 232, 1898.

[4] Op. cit., vol. xv, pp. 224, 225. Also Report of Excursion to Bishop's Stortford (1911): op. cit., vol. xxii, pp. 264 ff.

[5] Op. cit.: Excursion to Wokingham and Wellington College in 1890, with photograph of one of the sections, now obliterated and overgrown. Similar photographs presented at the time to this Association, and one was published in *Science Gossip*.

[6] See B.A. Report, 1910 (Section C), p. 616.

[7] [Pre-glacial valleys in Northamptonshire have been described by Mr. Beeby Thompson, Journ. Northants Nat. Hist. Soc., ix, p. 47, 1896, and xii, p. 207, 1904.—Ed.]

ANKER'S PIT.

POST-GLACIAL SERIES	1.	Gravelly loam.
	2.	False-bedded sand.
	3.	Stratified gravel.
	4.	Clay, 2 to 48 inches.
GLACIAL (PLEISTOCENE)	5.	Gravel (late-glacial) and clay containing palæoliths and remains of horse and of *Elephas primigenius* with erratics.
	6.	Stratified gravel with erratics.
	7.	Oxford Clay.

The deposits seen in Rippon's Pit may, I think, be taken as the equivalents of the upper three or four beds in Anker's Pit, while the lower series (5, 6) would seem to represent the succession in the pits of the London Brick Company, Nos. 1 and 4. There is much "contemporaneous erosion and filling-up"[1] in Rippon's Pit.

At No. 1 Pit (Old Fletton) the stratified fine sandy gravel is seen in open section extending down to the depth of 25 feet in the old channel and resting upon probably reconstructed Oxford Clay. Like the same gravels at No. 4 Pit, it contains erratics of considerable size, so that they would both seem to be sub-glacial, and to represent the 'ice-raft' stage of the later glaciation of the district. At both places they yield mammalian remains (including *E. primigenius*), and have the same character in structure and composition as that given above in detail for the No. 4 Pit. It is, however, a noteworthy fact that at the latter place they overlap the bank of the pre-glacial valley, with a deposit 8 or 9 feet thick, indicating the widespread shallow-water conditions of the later ice-raft stages of glaciation. That they are of later date than the great Chalky Boulder-clay is evident from the fact that a ridge of high ground some miles in length, to the south-east, consists of that deposit, in which I recognized erratics from the Chalk, the Lias, and the Carboniferous Limestone, when I visited it in company with Mr. Abbott, to whose courteous guidance over the district I am much indebted.

VII.—The 'Weathering out' of Striations upon Flint.

By J. Reid Moir, F.G.S.

FOR some time past I have had a difficulty in understanding how certain striated flints from various horizons stood, without breaking, the pressure to which they must have been subjected when such markings were imposed upon them. This difficulty increased when I found that thin flakes from the present land surface exhibited well-marked striæ, and as experiments with my presses had shown that even large flints will break up under no very great pressure, the possibility occurred to me of these scratches having altered since the flints were first subjected to the scratching process. I reasoned that if a point passed over a flint under pressure the area upon which the point impinged would be shattered, and that small plates or splinters of flint would be formed along the line of movement. I also concluded that, as with the thin plates which

[1] A term used long ago by F. B. Jukes.

are produced on a flint when flaking, and which are not found upon implements which have been exposed to atmospheric conditions, these fragments would in time, by thermal effects, 'weather out' and leave a clean-cut groove behind.

When I proceeded to test my theory by examining a series of striated flints in my collection I found various specimens which seem to me to show striæ in different stages of weathering. Thus one black glossy flint given me by Mr. E. St. H. Lingwood, of Westleton, Suffolk, and found by him on a ploughed field at that place, showed a shattered scratch extending for about 1¼ inches across its surface. To prove that such a scratch could easily be deepened I attacked part of it with a steel probe and found that I could easily remove the thin plates of flint which were produced when the initial shattering took place. I then took a pointed flint flake and cleared away the remaining splinters of flint in the groove I had made, and this specimen, therefore, now exhibits a shattered line over half its length, and the other half a deepish groove.

This question of the 'weathering out' of scratches appears to me to be of some importance, because what we have looked upon as deep striæ caused by great pressure are in all probability merely 'weathered out' scratches, the initial stage of which would not require any very great pressure to produce. I give it as my opinion that every scratch imprinted upon a flint must have a shattered portion on the sides and floor of the scratch, and, further, this shattered portion, if exposed long enough to thermal effects, must 'weather out' and the scratch alter in depth and appearance until all the thin fragments are gone. If a flint gets striated, and then becomes covered by some impervious material such as clay, then it will be protected from thermal changes and no 'weathering out' of the scratches take place. This perhaps offers an explanation for the smallness of the striæ on the flints from the Chalky Boulder-clay, as compared with those showing on stones from below the Red Crag. The latter were scratched and then exposed on the pre-Crag land surface, and consequently got 'weathered out', while those in the Boulder-clay have been protected by the nature of the material in which they lie, and many of them exhibit typical unweathered out, shattered, scratches. In this note I refer solely to the striæ which are developed upon the hard portion of the flints, not to those upon the softer cortex.

NOTICES OF MEMOIRS.

Geological Survey of Southern Rhodesia.

THE following is an abridged statement from the Report of the Director, Mr. H. B. Maufe, for the year 1912 (fol.; Salisbury, Rhodesia, 1913): As a result of the detailed work amongst the metamorphic rocks, it is becoming increasingly clear that they are divisible into three series, one of which consists of three groups: (*a*) a greenstone schist group, including epidiorite, (*b*) a banded ironstone group, and (*c*) a conglomerate and grit group. The second series consists of ultra-basic rocks, some of which contain chromite and asbestos. The third series comprises a very variable group of fine-grained and frequently schistose acid rocks, which have not hitherto

been recognized as a distinct series. Moreover, a consideration of the distribution of gold-bearing quartz reefs and the mode of occurrence of an important class of auriferous impregnations has led up to what is probably the point of greatest practical importance resulting from the year's work, namely, that the gold deposits of the Territory are closely associated with the last-named series of acid igneous rocks.

The north-western portion of the Wankie coal-field, including the main basin in which the colliery is situated, has been mapped by Mr. Lightfoot, whose geological work has determined the succession of rocks and the structure of this field. The discovery of fossil plants is interesting, as proving what perhaps was never seriously doubted by geologists, that the Wankie coal-beds belong to the lower part of the Karoo system. The main coal-seam is known to be a very thick one, and the best in the sub-continent for steam-raising purposes. The survey of the district now shows that the basin in which the colliery is situated, although bounded in parts by faults, is simple in structure, and remarkably free from faults and other disturbances. Estimates of the resources of the field made previous to the survey showed a very large reserve. Not only is this now confirmed, but a large addition may be made with considerable confidence. Mr. Lightfoot points out that probably 600,000,000 tons of coal could be taken out of the district mapped by him. Investigations were made, partly in conjunction with the Chemist to the Agricultural Department, into a number of deposits of limestone and clay, with special reference to their suitability for the manufacture of Portland cement; and a syndicate has proved by trial tests that such a cement, exceeding the requirements of the revised British standard specification in strength, etc., can be made out of materials occurring near Bulawayo, and that a sufficient quantity of them is available.

Observations on the relation of the soil, or more accurately the subsoil, to the underlying rocks have resulted in the collection of a considerable amount of evidence showing that the soils are largely residual accumulations, and that two of the most important factors in determining their character are (1) the nature of the underlying rocks, and (2) the behaviour of the soil-water.

REVIEWS.

I.—Caradocian Cystidea from Girvan. By F. A. Bather, M.A., D.Sc., F.R.S. Trans. Roy. Soc. Edinburgh, vol. xlix, pt. ii, No. 6. 4to; pp. 359–530, with 6 plates and 80 text-figures. Edinburgh: Robert Grant and Son, 107 Princes Street, 1913. Price 15*s.* 6*d.*

(PLATE XIII.)

IF we examine the various members in almost any grade of the Animal Kingdom we shall meet with some so unlike, *superficially*, our conception of the type, as to cause us, at first sight, to doubt their right to a place in the phylum to which they have been assigned by the systematist. But a careful study of the larval stages of development of many such erratic forms has usually led to the recognition of their true position. It is within the memory of the writer that *Lepas anatifera* was arranged with the Mollusca in the Shell

Gallery of the British Museum, and, at a much later date, the Brachiopoda and the Tunicata (1851–6) were still retained in textbooks in the same phylum, as a part of the Malacostraca.

As palæozoologists we are much indebted to Dr. F. A. Bather for having undertaken the study of the Echinoderma, of which he says it is "one of the best characterized and most distinct Phyla of the Animal Kingdom". Notwithstanding this encouraging introduction, we venture to think that this division contains many very difficult organisms to investigate, to which the author has devoted long years of careful and diligent study and made extensive acquaintance with both the literature of the subject and the specimens to be described. Particularly we must thank him for that admirable volume in 1900 on the Echinoderma.[1] In it Dr. Bather writes: "Nearly all the living animals included in this phylum, such as the sea-urchin (Echinoid), starfish (Asteroid), brittle-star (Ophiuroid), sea-cucumber (Holothurian), and sea-lily (stalked Crinoid), or feather-star (free Crinoid), can readily be distinguished through their possession of a radial symmetry, in which the number five is dominant; of a sub-epidermic skeleton composed of calcium carbonate with a characteristic micro-structure resembling trellis-work, and of a system of sacs, canals, and tubes that carry water through the body, especially by means of five radial canals from which small branches called *podia* are given off to the exterior. The extinct forms known as Blastoidea and Edrioasteroidea appear to have had a similar organisation, and the same statement may be made of most of the Cystidea"—the class which forms the subject of the present monograph.

In this his latest work the author presents us with a description of the Cystidea (one of the three extinct and most aberrant classes of the Echinoderms), collected from the Caradoc Beds (Ordovician) of Girvan, Ayrshire, by Mrs. Robert Gray, who has done so much to add to our knowledge of the fossils of this now historic locality. In this undertaking she has been fortunate in having had the co-operation of various palæontologists, including the late Professor H. A. Nicholson, Mr. Robert Etheridge, jun., Mr. F. R. Cowper Reed, Dr. F. A. Bather, and others.

"Though written" (says Dr. Bather) "in order to describe Girvan material, the memoir has grown to be little less than a monograph of the genera dealt with, and even includes the description of a new species from Bohemia. For this no apology is required. When a group of organisms has recently received adequate revision, new forms may on occasion be merely described and referred to their systematic position. In the present instance, prolonged study of allied species and genera proved a necessary preliminary to the understanding of the Girvan fossils, and if the descriptions of the latter are to be intelligible the reader must first be placed at the same point of view as the writer."

To show the geological distribution in Girvan of all the Cystid remains, both described and undescribed, the author adapts a portion

[1] Contributed to Sir E. Ray Lankester's *Treatise of Zoology* (assisted by Dr. J. W. Gregory and E. S. Goodrich), 8vo, 1900, pt. iii, pp. viii+344, and 309 text-figures.

of the Table of Girvan Strata drawn up by Messrs. Peach, Horne, and Macconochie (1901).[1]

LLANDOVERY—NEWLANDS SERIES.	
3. CAMREGAN GROUP. Grits, limestones, and shales. *Rastrites maximus.*	Bargany Pond Burn. Plate of a Glyptocystidean (?).
2. SAUGH HILL GROUP. Flagstones and shales. *Monograptus spinigerus.* *Rastrites peregrinus.*	Woodland Point. One plate and one base (?) of a Cystid (?).
1. MULLOCH HILL GROUP. Sandstones and shales; conglomerate. *Diplograptus acuminatus.*	
CARADOCIAN—ARDMILLAN SERIES.	
5. DRUMMUCK GROUP. Mudstones, Starfish Bed. *Dicellograptus anceps.*	Thraive Glen. Species of *Dendrocystis*, *Cothurnocystis*, *Cheirocrinus*, *Pleurocystis*.
4. BARREN FLAGSTONE GROUP. *Diplograptus truncatus.*	
3. WHITEHOUSE GROUP. *Dicellograptus complanatus.* *Pleurograptus linearis.*	Shallock Mill. Plates suggestive of *Echinoencrinus*.
2. ARDWELL GROUP. Flagstones and shales. *Climacograptus caudatus.*	
1. BALCLATCHIE GROUP. Conglomerate, mudstones. *Climacograptus bicornis.*	Ardmillan; a Glyptocystid (? *Cheirocrinus*) and plates α and β. Balclatchie; plates β (γ = Glyptocystidean) and ϵ (= Echinosphærid). Dow Hill; plates δ and ϵ, plates of *Cheirocr.* (?), and fragments indett.

The Starfish Bed, as its name implies, is prolific in Echinoderms. In addition to *Tetraster Wyville-Thomsoni* there are many Asteroidea, now being studied by Mr. W. K. Spencer. Though the Cystidea of the Starfish Bed are numerous in individuals, the number of species is small. Dr. Bather describes only nine species, of which eight are new, and it is, he thinks, quite possible that some future palæontologist will say these are twice as many as they ought to be. The genera represented are—

AMPHORIDEA HETEROSTELEA—	RHOMBIFERA—
Fam. Dendrocystidæ.	Super-fam. Glyptocystidæ.
Dendrocystis. 1 sp.	Fam. Cheirocrinidæ.
Fam. Cothurnocystidæ.	*Cheirocrinus*. 2 spp.
Cothurnocystis, n.g. 2 spp.	*Pleurocystis*. 4 spp.

The Amphoridea among the extinct Cystidea are defined by the author (p. 364) as "Primitive Cystidea in which radial symmetry has affected neither food-grooves, nor thecal plates, nor (probably) nerves, ambulacral vessels, nor gonads". In fact, they are most irregular forms of Echinoderma, and might well be styled as the 'Nonconformists' of their order, of which *Rhipidocystis* is an example

[1] "The Silurian Rocks in the South of Scotland" in *Fauna, Flora, and Geology of the Clyde Area*, Brit. Assoc. Glasgow, pp. 423–44.

(see p. 369, figs. 1–3, and p. 370, fig. 4) from the Ordovician of St. Petersburg. Here are also placed the species of *Dendrocystis*—

Described as having "a theca broader towards the column and composed of numerous plates irregular in size, form, and arrangement, the vent lateral and adcolumnal, the intake lateral and a-columnal and connected with a single skeletal process composed of four series of ossicles, with a stem proximally widening and composed of small widened ossicles, distally sub-cylindrical, gently tapering, and composed of elongate dimeres, and intermediately of transitional composition". (p. 369.)

We reproduce one example, namely, *Dendrocystis scotica*, Bather, sp. nov., Plate XIII, Fig. 3.

Altogether five species are enumerated, namely—

D. scotica, F. Bather, sp. nov. Upper Caradocian: Thraive Glen, Girvan. Op. cit., p. 374, fig. 9; p. 391, pl. ii, figs. 10–25.

D. Sedgwickii, J. Barrande. Zahorzan, Bohemia. Lower Caradocian: Girvan. Op. cit., p. 374, fig. 8; p. 387, pl. i, figs. 5–9.

D. paradoxica, E. Billings. Trenton Limestone: Quebec. Op. cit., p. 397, text-fig. 13; p. 396.

D. rossica, O. Jaekel. Upper Llandeilian: Esthland. Op. cit., p. 396, text-figs. 10–12.

D. Barrandei, F. A. Bather, sp. nov. Lower Llandeilian: Bohemia. Op. cit., p. 383, pl. i, figs. 1–4; p. 374, text-figs. 6, 7.

The next remarkable form from Girvan is referred to a new genus, *Cothurnocystis*, of which two species are named: *C. Elizæ*, F. A. Bather, gen. et sp. nov.,[1] and *C. curvata*,[2] F. A. Bather, sp. nov. Drummock Group, Starfish Bed: Thraive Glen, Girvan.

Cothurnocystis,[3] so named by the author from the outline of the frame being markedly boot-shaped, has its integumentary plates normally flat and tessellate, with subvective grooves of elliptical outline, occupying an area immediately adjacent and parallel to the curve of the boot sole (Plate XIII, Fig. 1).

On Plate XIII we give two figures, the obverse (Fig. 1) and reverse (Fig. 2) of one species, *C. Elizæ*, so named in honour of Mrs. Elizabeth Gray, to commemorate her zeal in collecting so rich a series, and her acumen in recognizing the peculiar shape and the Cystid nature of these extraordinary fossils. They were obtained from the Starfish Bed, Girvan. (p. 400.)

"This creature" (says Dr. Bather), "though plainly a Pelmatozoon, is so different in structure and outward form from any other Pelmatozoon as yet known that it is by no means easy to discover its true affinities. The very fact of this difference points to the conclusion that the animal was modified for some unusual habit of life; and our first task must be . . . to reconstruct from the dry bones the living organism." He then proceeds to describe the position of the *vent*, situated between two spines on the dorsal surface ("described as the leg of the boot"). "A vent of this nature implies a gut and a corresponding intake." (p. 413.)

After careful study and comparison with other forms, the author concludes that *Cothurnocystis* must have obtained its food by

[1] Op. cit., pp. 398–408, pl. iii, figs. 26–38, text-figs. 14–23.

[2] Op. cit., pp. 408–12, pl. iv, figs. 39–45, text-figs. 24–28.

[3] From κόθορνος (*cothurnus*), a high Grecian shoe, the foot-covering of tragic actors.

a subvective system of ciliated grooves,[1] and he shows that each of the elliptical organs was in part such a groove; that the rim is divided at about two-thirds the distance from its outer end into an inner *short* U and an outer *long* U, meeting by their free ends. The opening of the larger U was roofed in by an alternating series of movable cover-plates, and the opening of the short U was protected by its own bounding wall so as to form a hood which on occasion could meet the closed cover-plates, and so shut the whole opening. "Every known Echinoderm with a stem is a Pelmatozoon, and as such obtains its food by a subvective system of ciliated grooves, there is therefore no reason to suppose that in this respect *Cothurnocystis* was any exception. . . . When in full swing the cover-plates were open, the tentacles or podia were fully protruded, and a stream of sea-water was driven down each of the fifteen or more grooves, and diverted by the hood of the short U through the round mouth. Then if some passing animal brushed against a tentacle, the podia were quickly retracted, all the cover-plates shut down, and the hoods pulled up against them so as to close the mouths." (p. 415.)

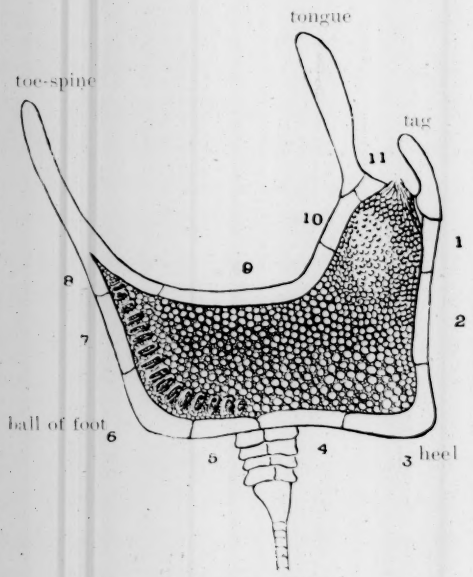
In what position did *Cothurnocystis* live? There is no trace of a root or of any means of attachment, and it is probable that the stem after gradually tapering was rounded off abruptly, and did not fix it in any way. The position of both intake and vent are on the *obverse* face; we may conclude, therefore, that the *reverse* face was directed towards the sea-floor. The extreme flattening and lateral extension of the theca lead to the conclusion that the whole skeleton lay flat on the sea-bottom. The knobs on the reverse side of the frame and the strut on that side served to give support to the flexible integument.

Remarkable as this form appears to be among the Cystidea, it is not alone, for *C. curvata* (save in the absence of the club-shaped spines upon its dorsal surface) is a near repetition of this prolate type (see text-figs. 24, 25, op. cit., p. 409), and *Ceratocystis Perneri*, Jaekel, from the Middle Cambrian of Bohemia, is also remarkable for its boot-like form (see p. 423, text-figs. 33, 34).

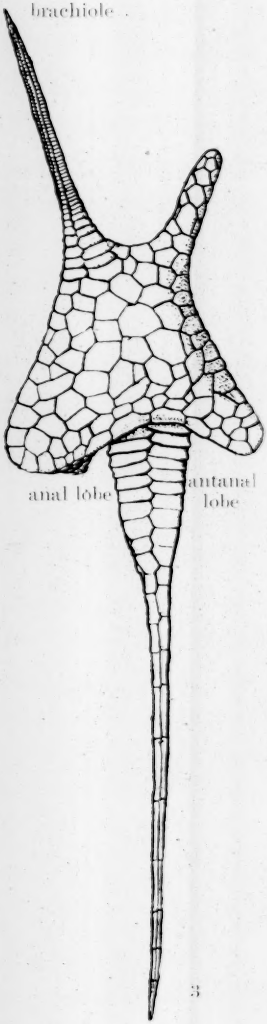
The Pelmatozoan life was a very simple existence: its members were mostly sedentary (if not always attached), receiving their food-particles along specially constructed food-grooves, subsisting, like their neighbours the Protozoa, Brachiopoda, Lamellibranchia, and Tunicata, on the currents made by their podia or cilia in the sea, which with its stream brought them the needful supply of aliment. Many of the more energetic members of the Eleutherozoa (the sea-urchin, starfish, and sea-cucumber) indulge in a predaceous and peripatetic existence, filling their stomachs with a selected and more attractive diet.

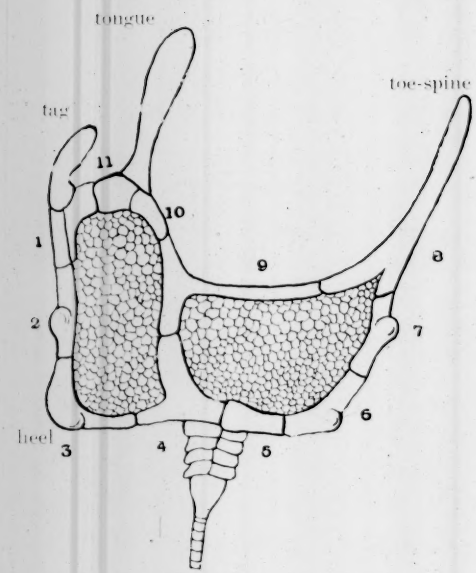
But we have already trespassed upon our allotted space, and can only refer to the ingenious explanation of the author (pp. 415–17) to show how *Colothurnus*, with the help of its short stalk, its flattened body, and its rigid frame, furnished with knobs and spines, sustained life by lying flat upon the sea-floor, and through all its vicissitudes always managed *to keep its right side up*.

[1] See Pl. XIII, Fig. 1 (a line of fifteen elliptical openings parallel to the marginal plates 5–7).



1. OBVERSE.





2. REVERSE.

1, 2, *Cothurnocystis Elizæ*. 3, *Dendrocystis scotica*.
Caradocian: Girvan, Ayrshire.

And now the reader must be left to follow the author through the 172 quarto pages of this most interesting monograph, so fully and finely illustrated. We have been permitted by Dr. Bather's kindness to reproduce three text-figures of two species from Girvan in our Plate XIII, which will show how divergent were these early forms of life among the Pelmatozoa.

H. W.

EXPLANATION OF PLATE XIII.

FIGS. 1, 2. *Cothurnocystis Elizæ*, Bather. Reconstructions of the two faces, based on the various specimens mentioned in the text. Probably no individual quite reached the size of these figures, though a few fragments come very near it. The numbers 1–11 refer to the marginals beside which they are placed. The proximal and median regions of the stem are drawn, with a few columnals of the distal region.

Fig. 1. The obverse face, showing the vent just below the number 11, the subvective system close to marginals 5–7, and the irregular rounded plates of the integument.

Fig. 2. The reverse face, showing the strut, the knobs on 2, 3, 6, 7, and the flattened plates of the integument.

FIG. 3. *Dendrocystis scotica*, Bather. Between the anal lobe and the stem the plates of the vent form a projection.

Both fossils are from the Starfish Bed in the Drummock Group, Thraive Glen, Girvan.

II.—THE WANDERINGS OF ANIMALS. By HANS GADOW. Cambridge Manuals of Science and Literature. Cambridge: University Press, 1913. Price 1*s*.

IN this little book of 150 pages Dr. Gadow has succeeded in giving a sketch of the distribution of animals which will be useful to students of geology and others seeking an introduction to this branch of science. Perhaps the most interesting chapter is that on the "Features of Environment", in which he describes the life of tropical forests, of deserts, and of high mountains as examples of contrasted habitats, and shows how these help or hinder the spreading of certain types of animals.

It is significant of the changed standpoint of modern zoogeography that the book does not contain one of the familiar maps showing the world divided into zoological 'regions'. Instead of it we have a series of maps, showing, in the first place, the actual distribution of certain selected groups of terrestrial vertebrates, and, in the second place, the changes in configuration of the great land masses in the successive geological epochs since the Trias. These latter maps, as Dr. Gadow is careful to explain, are to be regarded as tentative and hypothetical; "they will be objected to by the timid, on principle; critics with more expert knowledge will amend them." Of course, in a work of so wide a scope, inaccuracies in detail are likely to be discovered here and there by the specialist. There is no trustworthy evidence for the occurrence of crayfishes in Fiji or Melanesia (p. 92), or for the statement that "some existing species" of Scorpions "date back to the Coal-measures" (p. 93). Dr. Gadow's vigorous, though not always very careful, style has betrayed him on p. 15 into the assertion that "the search for generally applicable regions is a mare's nest"!

III.—Photographic Supplement to Stanford's Geological Atlas of Great Britain and Ireland. Arranged and edited by H. B. Woodward, F.R.S., with the co-operation of Miss H. D. Sharpe. 8vo; pp. 113, with 108 plates. London: Edward Stanford, Ltd., 1913. Price 4*s.* net.

A WARM welcome is assured to this supplement to the *Geological Atlas*. The editor, collecting his material from numerous sources, has selected 108 photographs of the most typical sections in the British Isles. Great care has been exercised in the choice of negatives, and the printing is good. The photographs are reproduced as half-page plates, each being accompanied by a brief explanatory notice with references to original publications and to the maps in the *Geological Atlas*. The arrangement is as far as possible chronological, and there is a good index of formations, localities, and authors, so that the book is one of ready reference.

IV.—Figure Stones.

On Palæolithic Figures of Flint found in the Old River Alluvia of England and France, and called Figure Stones. By W. M. Newton, F.R.Anthrop.Inst. Reprinted from the Journal of the British Archæological Association, March, 1913. 8vo. London: at the Bedford Press.

THE fantastic forms assumed by flints in the Chalk are familiar to everyone who has visited sections in the upper strata of that formation, and forms suggestive of many different kinds of animals—birds, beasts, reptiles, and fishes—have been rudely modelled by Nature. These have sometimes been actually taken to represent the creatures themselves in a fossilized condition, as in the "Facts and Fossils adduced to prove the Deluge of Noah", by Major-General Twemlow (see Geol. Mag. for 1869, p. 81). In other geological formations nodules of ironstone and argillaceous limestone sometimes assume forms suggestive of different animals, as in the concretions of the Champlain Clays of the Connecticut Valley, described by Mr. J. M. A. Sheldon (see *Nature*, April 11, 1901).

The specimens to which Mr. Newton directs special attention have been obtained by him and by workmen in his employ from a gravel-pit at Dartford in Kent, and they consist of flint-stones that have probably in all cases been naturally derived from the Chalk and embedded in the ancient valley gravel. At the same time it is not impossible that Palæolithic Man might have picked up some flints from the talus of a chalk cliff.

Forms described and figured by Mr. Newton have rude resemblances to fishes, birds, a tortoise, deer, horse, rhinoceros, elephant, etc., but he does not as a rule suggest any definite identification. The allegation is that these and other stones attracted the attention of Palæolithic Man, that he recognized a rude sort of animal form, and touched up the stones, where he could improve the resemblance, by chipping cavities for eyes, nose, or mouth, and in other ways slightly modifying the natural shape of the flints. There is nothing absurd or impossible in the suggestion. The pictorial engravings of various

animals on stone, bone, horn, and ivory, from cavern deposits of Palæolithic age, are well known, and figure stones have been regarded as "first attempts at sculpture by Prehistoric Man". In considering the subject it is especially interesting to know that Boucher de Perthes in 1849 had figured flints suggestive of animal forms, and later on in 1861 (as pointed out by Mr. Newton) he drew attention to the importance of observing whether the stones had been notched or otherwise chipped so as to indicate the handiwork of man.

It was early in 1902 that Mr. Newton discovered his first figure stone from the Dartford gravel. The deposit there is about 18 feet thick and about 65 feet above O.D., and Mr. Newton obtained permission to collect any curious stones and to receive the aid of the workmen in putting aside similar specimens. At the end of the year the pit would have been closed, but as "such remarkable examples of figure stones with intentional work upon them" had been obtained, Mr. Newton arranged to work the pit at his own expense, and for a further period of five years some 5,000 tons of gravel were excavated and examined. He remarks that "At an early period of my enquiry it became evident that I had chanced upon the site of a Palæolithic settlement of great antiquity—implements, cup-stones with worked rims, rings of flint, anvils (so-called), and many curious shapes in worked flint made their appearance; among the latter the forms of animal heads predominated, the cups taking next place in point of numbers, implements [occurring] in very small quantity considering the vast amount of gravel excavated". At Swanscombe, on the other hand, the gravels have yielded numerous implements but very few cup-stones, and rarely a figure stone. Thus Mr. Newton points to the two settlements as affording evidence of distinct industries. It is indeed remarkable that the figure stones should be thus locally abundant, a fact which supports the view that many were intentionally gathered together by man.

The careful particulars given by the author, and his impartial explanation of them, deserve all consideration.

V.—Phosphates of Egypt.

Topography and Geology of the Phosphate District of Safaga (Eastern Desert of Egypt). By John Ball, D.Sc., F.G.S., Ministry of Finance. Survey Department, Egypt. Paper No. 29. Cairo, 1913.

SAFAGA is a small district on the Red Sea just to the south of the Gulf of Suez. The phosphate deposits occur on either side of the Wadi at distances of from 12 to 22 kilometres inland. The Um-el-Huetat mines are connected by railway with the port, and the climate is said to be extremely healthy. The geology consists of Alluvial beds, Eocene limestones, etc., Upper Cretaceous limestones and marls, Phosphate beds and cherts, also of Upper Cretaceous age, Nubian sandstones, and Crystalline rocks. Fossils are scarce, but "the beds are doubtless of Danian age". Maps, sections, and views accompany the paper, which concludes with a complete list of all publications issued by the Survey Department up to date.

"A Brief Note on the Phosphate Deposits of Egypt," by Dr. John Ball, has also been published as Survey Department Paper No. 30 (Cairo, 1913). The author calls attention to the extensive beds of phosphate of lime which occur in various parts of the deserts of Central Egypt, in sedimentary strata belonging to the Upper Cretaceous system. Their commercial value was pointed out by the Geological Survey in 1900, and it is highly satisfactory to learn that while the output in 1908 was 700 tons, and in 1911 as much as 6,425 tons, in 1912 it was 69,958 tons.

VI.—Department of Mines, Canada.

WE have received vols. v and vi, which complete "An Investigation of the Coals of Canada with reference to their Economic Qualities", by Messrs J. B. Porter and R. J. Durley (1912).

We have also received a work entitled "Tourbe et Lignite, leur Fabrication et leurs Emplois en Europe", by Mr. E. Nystrom (1913). In this volume the author gives the results of a personal study of the industries connected with peat and lignite (or Brown Coal) in various parts of Northern Europe, the object being to aid the development of the peat industry in Canada. The methods and processes of working peat were examined in Sweden, Norway, Finland, Russia, Denmark, Holland, and Austria; and of peat and lignite in Germany. The volume is mainly of technical interest; the author gives a brief account of the classification and composition of peat, and then passes on to practical matters, giving detailed accounts of his observations, with illustrative plates and text-figures of implements and machines employed in the cutting of peat and in its fabrication into various forms of fuel. There are views of the excavations, of blocks and stacks of peat, and of methods of transport. Accounts are also given of the uses of peat for moss-litter and other economic purposes.

We have further received the Annual Report on the Mineral Production of Canada for the year 1911 (1913), by Mr. John McLeish. The chief products are copper, gold, iron, lead, nickel, silver, asbestos, coal, gypsum, petroleum, pyrites, quartz, and salt.

VII.—The Magnetic Iron Sands of Natashkwan, County of Saguenay, Province of Quebec. By G. C. Mackenzie. 1912.

THIS has been published as a separate report. The Iron Sands consist chiefly of quartz, felspar, garnet, olivine, magnetite, and ilmenite, and they occur on the north shore of the lower St. Lawrence river and gulf. The deposits vary much in extent and thickness, and they appear worthy of practical attention in not more than three or four localities. To be of commercial value it is necessary to separate not only the magnetite and ilmenite from the other minerals, but also the major part of the ilmenite from the magnetite. Only one serious attempt has been made to concentrate and smelt the magnetite. This was at Moisie, about 330 miles east of Quebec City; but the works have been closed. It is pointed out that the Natashkwan sands constitute one of the most promising of the deposits, as there is a treeless dune area which "contains at least 500,000 tons of magnetic iron concentrate that will average 67 per cent in iron".

VIII.—Brief Notices.

1. Permo-Carboniferous Ice Age in Western Australia.—This subject was dealt with by Mr. A. Gibb Maitland in his Anniversary Address to the Natural History and Science Society of Western Australia (vol. iv, session 1910–11). The essay is well illustrated by map, sections, and photographic views.

2. Geological Survey of South Australia.—In Bulletin No. 2 (1913), the Government Geologist, Mr. L. Keith Ward, discusses the possibilities of the discovery of petroleum on Kangaroo Island and the western coast of Eyre's Peninsula, and comes to the conclusion that the facts do not justify the expenditure of capital in boring for oil. Some account is given of the rubber-like material known as 'coorongite', but there appears to be no genetic connexion between it and petroleum.

3. Mining in South Australia.—The *Review of Mining Operations* in the State during the half-year ended December 31, 1912 (No. 17, 1913), gives satisfactory accounts of the production of copper, gold, and silver; other minerals obtained include lead and iron ores, uranium ores, gypsum, and graphite.

4. Indian Aerolites.—G. de P. Cotter, B.A., contributes "Notes on Indian Aerolites recorded since 1906" (Rec. Geol. Surv. India, vol. xlii, pt. iv, p. 265). The paper gives details of six falls, viz., Vishnupur, Chainpur, Mirzapur, Baroti, Khohar, and Lakangaon. It is admirably illustrated by fourteen photographs of separate stones, and by a map of the Chainpur fall. The mineral constitution of the stones is only discussed very briefly.

5. The Bernese Jura.—The structure of the Bernese Jura finds an able expositor in Dr. P. Schlee, who in an interesting paper published in the Mitth. geogr. Gesellsch. Hamburg, xxvii, 1913, illustrates his remarks with a fine series of photographic reproductions, a map, and sections. The paper can be obtained separately from Friederichsen & Co., Hamburg, for 3 marks.

6. Termites and Geology. — Mr. Donald Steel writes in the *American Naturalist*, July, 1913, on this subject. He does little more than record the facts, but we gather from a perusal of his paper that the work of the Termites is much like that of worms, a turning over the surface soil. The Termite, however, piles the soil up into hillocks, which are themselves worn down again by storms, and gradually spread over the surrounding country.

7. The Landes of Gascogny.—M. Edouard Harlé (Bull. Soc. géol. France (4), xii, 1912) has investigated the Landes of Gascogny, and comes to the conclusion that far from being extremely old and entitled to the term 'Pénéplaine landaise' of authors, these tracts are quite modern and still in process of formation. They are due to the prevalent westerly winds, are of different ages, and continually changing. In the same communication Harlé traces the changes in the bed of the River Adour, the struggle between that river and the dunes, and their influences on each other.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 25, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

Mr. C. Dawson, F.S.A., F.G.S., exhibited zinc-blende occurring in ironstone nodules which contain plant-remains, in the celebrated plant-bed of the Fairlight Clays, Fairlight, near Hastings. He remarked that the form is crystalline and the ore is frequently found filling up cavities left by the decayed vegetable matter. Zinc-blende is not known to occur at other horizons in the Weald, nor anywhere else in the South-East of England. It is probably segregated from older rocks of which the Wealden strata are composed.

He also exhibited pisolitic limonite, which occurs in considerable quantities at one or two horizons in the Fairlight Clays, near Hastings. On the shore at Pett Level, near Fairlight Cliff end, a very large deposit is found, just above the ordinary high-water mark. The deposit consists of minute spherical grains or nodules of sand-like condition. These, on being analysed, prove to contain 60 per cent of iron-oxide. In the cliff the iron-ore occurs in bands, the grains of which it is composed forming a compact grey conglomerate that turns dark brown on exposure. Many pieces of the conglomerate are to be found on the shore in a rolled condition. When disintegrated, they are deposited by the joint action of the eastward drift of the tide and the south-westerly wind along the shore. The deposit last year measured about half a mile in length, by about 30 or 40 yards in width, and was 3 to 4 feet deep.

The following communication was read:—

"The Miocene Beds of the Victoria Nyanza and the Geology of the Country between the Lake and the Kisii Highlands." By Felix Oswald, D.Sc., B.A., F.G.S.; with Appendices on the Vertebrate Remains, by Charles William Andrews, D.Sc., F.R.S.; on the Non-Marine Mollusca, by Richard Bullen Newton, F.G.S.; and on the Plant-remains, by Miss N. Bancroft, B.Sc., F.L.S.

The Miocene beds of the eastern coast of the Victoria Nyanza, south-east of Karungu, form a narrow zone (covered with black earth) at the foot of cliffs of overlying nepheline-basalt, and are only exposed in a few gullies. The whole series is conformable, dipping 8° north by west.

1. Beds 1–12. An upper group, about 70 feet thick, of grey and brown clays and shales, with occasional current-bedded sandstones containing terrestrial shells (*Tropidophora*, *Cerastus*), as also calcified tree-stems in the uppermost bed.

2. Beds 13–25. A middle group, about 30 feet thick, of red and grey clays, with white sandstones in the lower half. No bone-bed, but fragmentary Chelonian and Crocodilian remains occur sparsely throughout the series. Persistent horizons are a travertinous marlstone (No. 14) containing *Ampullaria* and *Lanistes*; a thin sandstone (No. 16) yielding Hyracoid jawbones; and a gravel (No. 24) yielding teeth of *Dinotherium*, *Protopterus*, crocodile, etc.

3. Beds 26–37. A lower group, about 35 feet thick, of current-bedded sandstones and gravels passing down into clays and marlstones. A conglomerate of calcareous nodules overlies gravelly sandstones (No. 31) containing isolated bones of *Dinotherium*, Anthracotheroids, rhinoceros, giant tortoises, etc., indicating a Lower Miocene (Burdigalian) age, with *Ampullaria*, *Cleopatra*, and terrestrial shells (*Cerastus*).

These fluviatile sediments were deposited in a lagoon, and were derived from gneisses, andesites, and quartzites that still occur in situ to the eastward. Calcareous springs acted intermittently, and the sediments became finer and less fossiliferous as the river-system reached its base-level.

The series overlies gneisses and amphibolites, with a north-north-westerly and south-south-easterly strike. In searching for the extension of these beds the author found them to be completely denuded on the south, while on the north they disappear beneath the basalt-plateau. Marching up the Kuja Valley, he found the upper beds lying on old andesite 15 miles inland, on the line of strike. Evidence is adduced of the lake having stood about 330 feet above its present level, and of a rejuvenation of the rivers since the formation of a gneissic peneplain, above which the Kisii Highlands rise in steep escarpments of ripple-marked, unfossiliferous, quartzitic sandstones, probably Devonian, separated from the underlying gneisses and schists by an extensive dolerite-sill. From Kisii the peneplain was traversed to the region of nepheline lavas near Homa Bay. Lake Simbi, an explosion-crater, was investigated; and a Pliocene series was found north of Homa Mountain.

The vertebrate remains described by Dr. C. W. Andrews include Proboscidea, Hyracoidea, Artiodactyla, Rodentia, and Reptilia, and fully support the suggested occurrence of Lower Miocene deposits on the shores of the Victoria Nyanza. A deposit of probably Pliocene age yielded a new (?) species of *Elephas*, also bones of antelopes and baboons.

The non-marine Mollusca associated with the Miocene vertebrates are freshwater and terrestrial shells which all belong to existing species. Only *Ampullaria*, however, still occurs in the Victoria Nyanza, while *Lanistes carinatus* is not found nearer than the Tana River, and the nearest recorded locality for *Cleopatra bulimoides* is in the Lake Rudolf region and Mombasa. Among the terrestrial shells, *Burtoa* is the sole genus occurring near the Victoria Nyanza; the other forms (*Cerastus*, *Tropidophora*, *Achatina*) are found at considerable distances therefrom. The total absence of Pelecypoda is also interesting.

On Wednesday, June 18, 1913, a Conversazione, at which about three hundred ladies and gentlemen were present, was held in the Society's apartments, from 9 to 11.30 p.m. In the course of the evening, lectures, illustrated by lantern-slides, were delivered by Professor W. W. Watts, F.R.S., on "The Buried Landscape of Charnwood Forest", and by Captain H. G. Lyons, F.R.S., on "The Marshes of the Upper Nile", and many interesting exhibits were shown.

The next meeting of the Society will be held on Wednesday, November 5, 1913.

CORRESPONDENCE.

MICRASTER PRÆCURSOR, ROWE.

Sir,—Your reviewer of *The Stratigraphy of the Chalk of Hants* in the March Geol. Mag., 1913, pp. 122–3, seems to have misunderstood my remarks on this species; at any rate, the views from which he appears to be dissenting are not views advocated or held by me. I should therefore like to restate the points I intended to raise.

In the first place it appears to me that Dr. Rowe's monograph in effect established that every individual of the species *M. præcursor* possesses two sets of characters, which have practically nothing in common. The first set embraces a large number of characters which the individual shares with all specimens, not only of *M. præcursor*, but also of *M. cor-testudinarium* (and sometimes other species also) from the same horizon; these characters are therefore of great zonal value, but no specific value. The second set embraces a small number of characters which enable *M. præcursor* to be distinguished from its nearest ally, *M. cor-testudinarium*. As neither of these species is confined to a single zone, this second set of characters are not strictly of any *zonal* value; i.e., a record of *M. præcursor* does not identify the zone, but it only tells you that you are in one of two or (under Dr. Rowe's zonal classification) three zones. To put it briefly, the assemblage of individuals defined as the species *M. præcursor* has no zonal value; the individuals have, through characters which are not specific, great zonal value. (I did not expressly affirm the latter proposition because I regarded it as established beyond dispute; but your reviewer seems to have failed to perceive that the two propositions are quite independent, and to have assumed that a challenge of the general view on one must necessarily be a challenge of the general view on the other.)

Secondly, on examining the characters by which *M. præcursor* is to be distinguished from *M. cor-testudinarium* they appear to consist substantially of shape variations in a particular direction, that of the proportion between length and breadth, with concurrent variations in minor features necessarily affected by variation in general shape. That is to say, the species *M. præcursor* is based almost entirely upon shape variations, while the prime object of Dr. Rowe's monograph was to prove that shape variations were not a valid basis for species of *Micraster*. This seems to indicate that *M. præcursor* is not specifically separable from *M. cor-testudinarium* as defined by Dr. Rowe, but that they are two sections of a single species which obviously must be known as *M. cor-testudinarium*, and that *præcursor* should be suppressed as a specific name. This does not in the least prejudice the zonal value of the individuals hitherto comprised in the species *M. præcursor*.

Thirdly, it is legitimate to inquire whether the *præcursor* section of the species *M. cor-testudinarium* is a natural one, for which '*præcursor*' can usefully be retained as a varietal or other subsidiary name. It seems to me that if it is a natural section, the dividing-line employed by Dr. Rowe ought to occupy the lowest, or nearly the lowest, point in a curve of frequency plotted for the various proportions

between length and breadth in a large and representative series. I very much doubt whether this would be found to be the case.

Your reviewer tends to beg these questions by treating of the "*group of Micraster præcursor*". This phrase would, of course, be a well-recognized one to denote several allied species, among which *M. præcursor* is prominent. That may be the sense in which he uses it, but probably it is not so, for in that case his criticism would not be relevant to my remarks, as I only challenged one species, not several. I suspect that the phrase is current, and was used by your reviewer, to designate just the assemblage which Dr. Rowe named *M. præcursor*; and that the vague word 'group' has been added to a term which can only legitimately denote a species owing to a sub-conscious feeling that the assemblage in question is not satisfactory as a species. If so, the use of this expression tends to confirm my views; but in any case it is in itself so ambiguous that its use without a definition of its scope, for the time being, is to be deprecated.

R. M. Brydone.

27 Twyford Mansions, W.
August 16, 1913.

THE DIVISION OF THE UPPER CHALK.

Sir,—With respect to the scientific points raised by Mr. Brydone, they have really little to do with the division of the Upper Chalk into two stages. He only concerns himself with the line of division between his two zones of *Offaster pilula* and *Actinocamax quadratus*. The main question is this—suppose French geologists are right in believing that there are two faunas of stage-value in the comprehensive Senonian of d'Orbigny, where do we find the most convenient plane of division between them? At present they draw the line at the top of the zone of *Marsupites*; I gave reasons for drawing it at the top of a higher zone, that of *Placenticeras bidorsatum* and *Inoceramus lingua*, which though recognized has not yet been fully examined and defined in France.

This latter zone must be more or less coextensive with Mr. Brydone's zone of *Offaster pilula*, and if he can substantiate his zone and his upper limit of it throughout the South of England, it should also be applicable to the Paris Basin, and may eventually become the plane of division between a restricted Senonian and a Campanian stage, as suggested by me last year: that is the real point which requires further investigation.

Meanwhile I am quite prepared to agree with Mr. Brydone that the Yorkshire Upper Chalk is so decidedly North German in its affinities that its nomenclature should be North German rather than Anglo-Parisian. Let the discussion of the subject be limited at present to the Anglo-Parisian region, but here a caveat must be entered. It is well known that the species which go by the names of *A. granulatus* and *A. quadratus* are connected by a number of intermediate forms, and that Mr. Rowe regards the one as the lineal ancestor of the other. Mr. Brydone will have to define exactly what he means by *A. quadratus* and what he regards as the distinction

between the two species, for it may be that his *A. quadratus* is not exactly what Mr. Rowe has taken to be the typical form of that species. The latter informs me that he never found anything really approaching his idea of *A. quadratus* in Sussex. Mr. Brydone may have been more fortunate, but on the other hand it may be that his finds would be regarded by Mr. Rowe as extreme forms of *A. granulatus*.

A. J. Jukes-Browne.

Torquay.
August 6.

OBITUARY.

PROFESSOR JOHN MILNE,

D.Sc., F.R.S., F.G.S., Hon. Fellow of King's College, London.

Born December 30, 1850. Died July 31, 1913.

It was only in August,[1] 1912, that we published in our list of Eminent Living Geologists a notice of the life and work of our dear friend John Milne. This August we received from Shide the sad news of his decease in his 63rd year. There is little to add to the record we published a short year ago. Seismographic stations extend over nearly the whole globe. Each station owes its inception to Professor Milne. The records which are maintained by his seismographs at Shide are automatically carried on as if he was still there; and after the meeting of the British Association in September it will be decided where and by whom the work shall be continued as a permanence. Such splendid observations cannot be allowed to lapse, for they interest not one country but every land and every nation. The work Professor Milne has given to the world cannot be permitted to die.

MISCELLANEOUS.

Mr. F. P. Kendall, jun., assistant curator of the Zoological Museum of the University of Sheffield, and son of Professor Kendall, of Leeds University, has been appointed lecturer in zoology and geology in the South-Eastern Agricultural College at Wye.

Mr. W. G. Fearnsides, M.A., F.G.S., Fellow and lecturer in Natural Sciences at Sidney Sussex College, and demonstrator in petrology in the University of Cambridge, has been appointed to the Sorby Chair of Geology at Sheffield.

Trustees of the British Museum.—Sir Archibald Geikie, K.C.B., Pres. R.S. (late an ex-officio Trustee of the British Museum), was elected on June 2 a member of the Standing Committee of that body in place of the late Lord Avebury.

Professor J. W. Judd, C.B., LL.D., F.R.S., has been elected by the Council Emeritus Professor of Geology in the Imperial College of Science and Technology.

[1] See Geol. Mag., August, 1912, pp. 337–46.